GOVERNMENT OF THE PUNJAB

PUBLIC WORKS DEPARTMENT

IRRIGATION BRANCH

REPORT

OF THE

Crop Planning Committee

BHAKRA CANAL AREA

सत्यमेव जयते

SIMLA

OCTOBER, 1954

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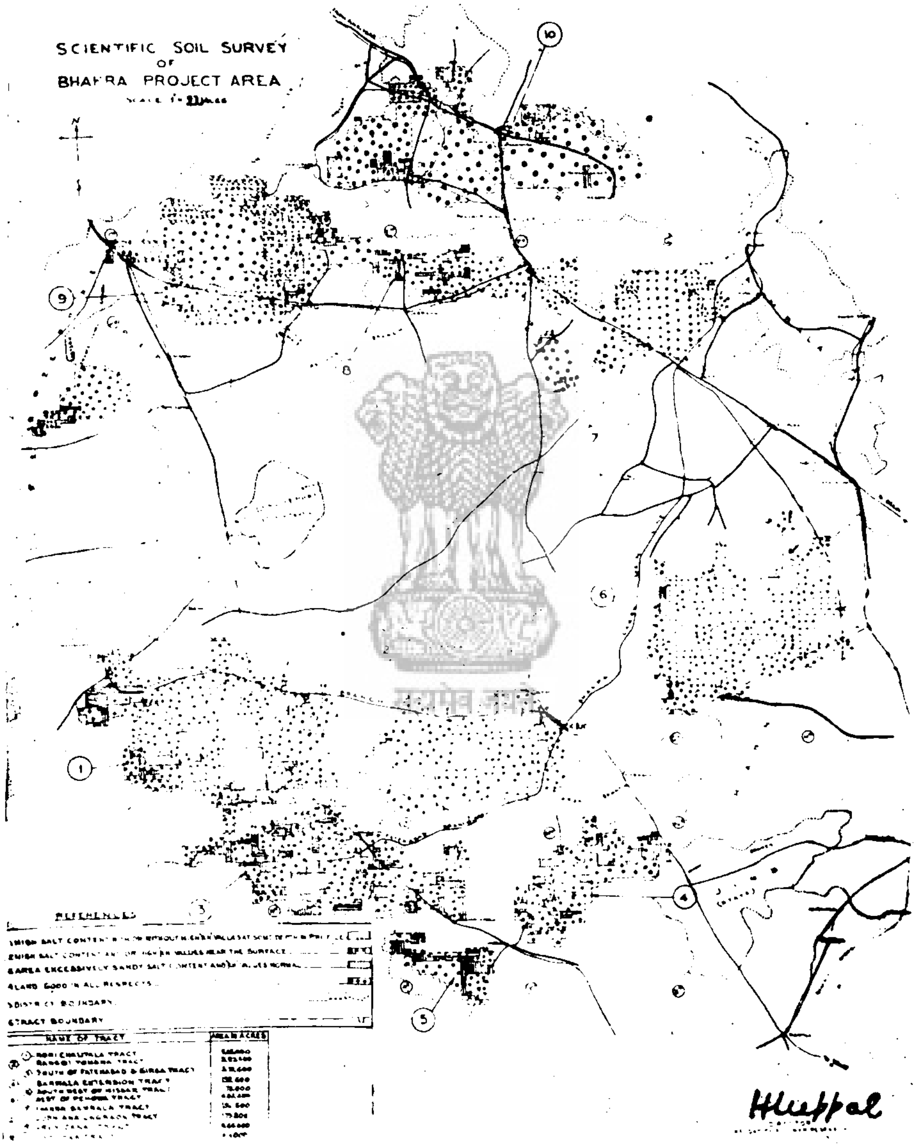
SCIENTIFIC SOIL SURVEY
OF
BHAKRA PROJECT AREA
SCALE 1" = 8 MILES
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REFERENCES
1 HIGH SALT CONTENT WITH OR WITHOUT HIGHER pH VALUES AT SOME DEPTH IN PROFILE
2 HIGH SALT CONTENT AND OR HIGHER pH VALUES NEAR THE SURFACE
3 AREA EXCESSIVELY SANDY SALT CONTENT AND pH VALUES NORMAL
4 LAND GOOD IN ALL RESPECTS
5 DISTRICT BOUNDARY
6 TRACT BOUNDARY
NAME OF TRACT
AREA IN ACRES
NORI CHAUTALA TRACT
RANGOI TOHANA TRACT
SOUTH OF FATEHABAD & SIRSA TRACT
BARWALA EXTENSION TRACT
SOUTH WEST OF HISSAR TRACT
WEST OF PEHOWA TRACT
TARSA BARWALA TRACT

HLUppal

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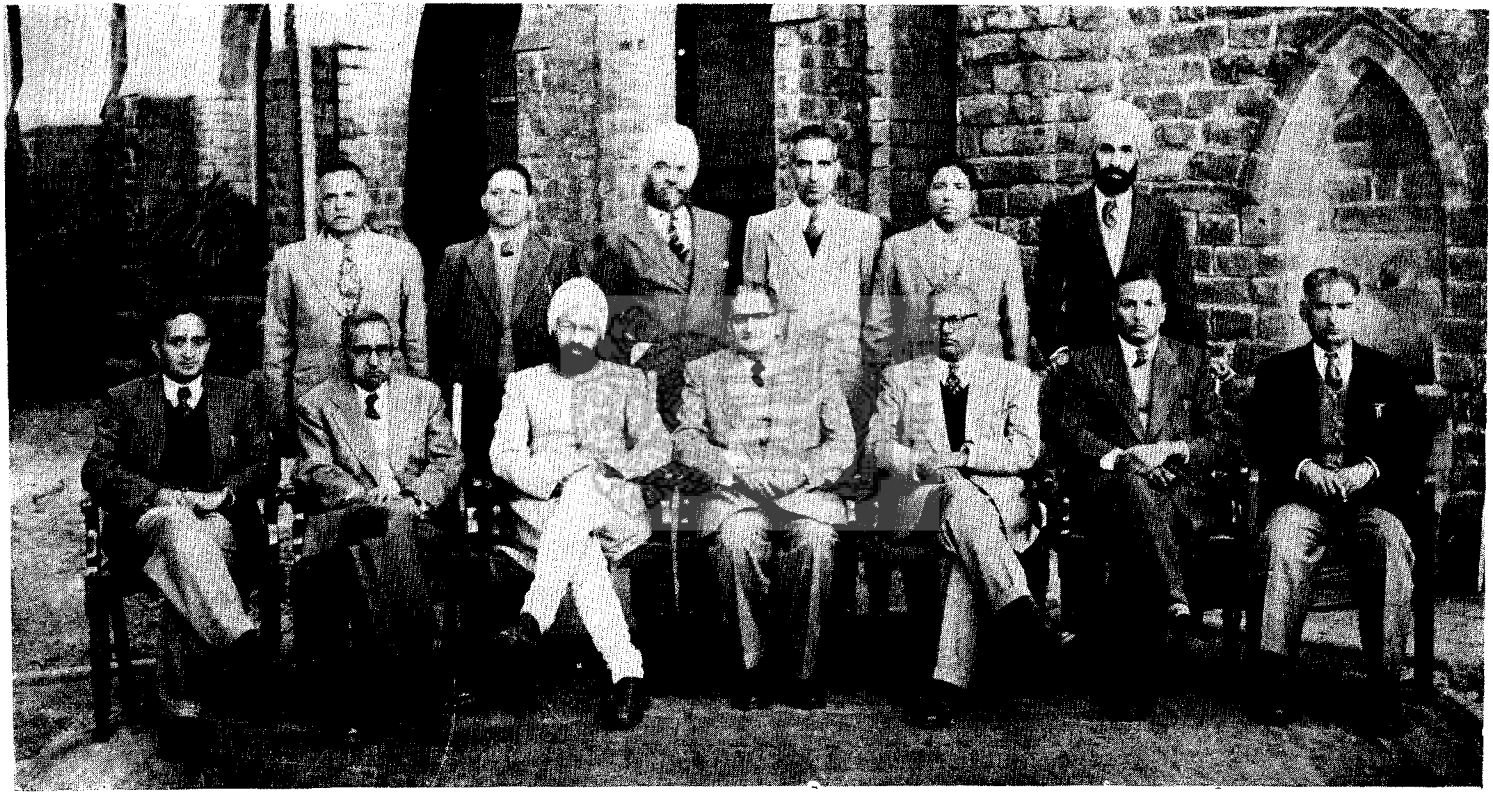
CROP PLANNING COMMITTEE

BHAKRA CANAL AREA.
P. W. D. Irrigation Branch. Punjab.
18th October—1954.



(L. to R.) Chairs :—Sarv Shri J.R. Tandon, (Member) M.L. Mehta, (Member) Kapoor Singh, M.L.C., (Member) R.R. Handa, I.S.E., (Chairman) R.K. Gupta, I.S.E. (Member)
H.L. Uppal, (Member) Jagat Singh Bali. (Agri, Deptt). K. S. Malik (Secv:Rtd.) K. R.Chowdhry, (Secv: Rtd.) Pala Ram, (Elect. Branch Panjab) Ajmer Singh (Dept. of Industries)
Standing:-Sarve Shri Walaiti Ram U.S. Dalal,

1. COMMITTEE.

1.	Shri R. R. Handa, I. S. E., Chief Engineer, Bhakra Canals.	(Chairman)
2.	Shri Kapoor Singh, M. L. C., Ludhiana	(Member)
3.	Shri Gopi Chand Gupta. M. L A., Karnal.	,,
4.	Shri Darbara Singh, M. L. A., Jullundur.	,,
5.	Shri Devi Lall, M. L. A., Hissar.	,,
6	Shri Teg Ram, M. L. A. Ferozepur.	,,
7.	Shri R. K. Gupta, I. S. E., Chief Engineer, Projects.	,,
8.	Chief Engineer, Electricity Branch, Punjab.	,,
9.	Director of Agriculture, Punjab.	,,
10.	Dr. H. L. Uppal, Director, Irrigation Power Research Institute.	,,
11.	Director of Industries, Punjab.	,,
12.	Shri R. L. Anand, Economic & Statistical Adviser, Punjab.	,,
13.	Shri M.L. Mehta, Ex. Director, Land Reclamation, Punjab.	,,
14.	Under Secretary, (Revenue) to the Financial Commissioner, Punjab.	,,
15.	Shri S. D. Kalra, O. S. D. and Shri J. R. Tandon, Under Secretary, Bhakra Canals.	,,
16.	Shri Walaiti Ram, Superintendent, Finance (Special).	,,

Secretary

1.	Shri K. S. Malik.	(from 22.2.52 to 30.4.54)
2.	Shri K. R. Chowdhry.	(from 1.5.54 to 28.2.55)

CHAPTER I.

INTRODUCTION

1. Appointment of the Committee :—

The Crop Planning Committee for the areas to be served by the Bhakra Canals was appointed vide P W.D. Irrigation Branch, Punjab Government U. O. No. 9933/BC dated the 9th November, 1951 and its constitution was published in the Public Works Department, Irrigation Branch, Gazette Notification No. 48/CPC/162/51 dated the 8th March, 1954, reproduced below.

> "The Punjab Government is pleased to constitute a Crop Planning Committee for areas served by the Bhakra Canals, with effect from 4-9-1952. The following will be the members of the Committee."

1. The Chief Engineer (Bhakra Canals) and Secretary to Government, Punjab, Irrigation Branch. (Chairman)
2. Sardar Kapoor Singh, M.L.C , Chairman, Punjab Legislative Council. Member
3. Shri Gopi Chand Gupta, M.L.A. „
4. Sardar Darbara Singh, M.L.A. „
5. Ch. Devi Lall, M.L.A. „
6. Master Teg Ram, M.L.A. „
7. Chief Engineer, Electricity Branch Punjab „
8. Chief Engineer (Projects) P.W.D. „ Irrigation Branch. „
9. The Director of Agriculture Punjab. „
10. The Director of Industries, Punjab. „
11. The Economic and Statistical Advisor to the Government Punjab. „
12. The Director of Irrigation & Power Research Institute, Amritsar. „
13. Shri M. L. Mehta, Retired Director, Land Reclamation, I.B. Punjab. „
14. The Under Secretary (Revenue) to the Financial Commissioner, Punjab. „
15. The Assistant Secretary to the Government Punjab, Finance (Works) Department.
16. Shri S. D. Kalra, Officer on Special Duty, (Establishment) P.W.D. Irrigation Branch.

2 Terms of Reference :-

The terms of reference of the Committee will be :-

(*i*) To consider

(*a*) The most suitable predominant crops, and the ways and means of obtaining this;

(*b*) The areas requiring reclamation, the technique to be adopted and the organization that is to be created for this purpose;

in the light of :-

(*a* Scientific soil surveys of Bhakra areas;

(*b*) Crop experiments made by various departments;

(*c*) Rain fall;

(*d*) Water allowance approved for different areas to be served by the Project;

(*e*) Proximity to large towns, or other industrial areas.

(*ii*) To assess the changes that are likely to occur in the soil on the introduction of the canal irrigation, to study factors which are operative in bringing about deterioration of the land and the decrease in the yield and to suggest measures to prevent this deterioration.

(*iii*) To determine the nature and amount of artificial fertilizer required, the source from which it should be obtained and the method of distribution amongst the cultivators.

(*iv* To suggest suitable legislation, if any, required for the implementation of recommendations.

3. Period of work :-

Shri Kirpal Singh Malik joined as Secretary, Crop Planning Committee on 22nd February, 1952 and engaged himself in the work of collecting facts and figures on the subject of Crop Planning which was quite a new type of work in the State. The selection and nomination of the members was completed in September, 1952 when five M.L.As. whose names appear in the list of the members on page 1 were nominated by the Government to work as Non-official members of the Committee. The first meeting of the Committee was held on 13th December, 1952 in the Committee Room of the Punjab Civil Secretariat, Ellerslie, Simla-2 when following items on agenda were discussed :-

1. Consideration of the note by Shri R. R. Handa, I.S.E., Secretary to Government, Punjab, P. W. D. Irrigation Branch. (Appendix A).

2. General discussion on the report of the Scientific Soil Survey of the areas to be irrigated by Bhakra Canals submitted by the Director, Irrigation & Power Research Institute, Punjab, Amritsar (Appendix B).

3. Distribution of work relating to Crop Planning amongst the technical members namely, Director of Agriculture, Punjab, Director of Industries, Punjab and the representatives of the Electricity Branch and Financial Commissioner, Punjab.

4. Any other points for consideration.

The main decision taken as a result of the deliberations of the Committee was the formation of two Sub-Committees to be discussed in the next paragraph. In all, the Committee held 10 meetings and the Legislation and Crop Pattern Sub-Committees held 11 and 7 meetings respectively during the period. The experts and the Heads of Departments prepared detailed notes on their subjects concerning the terms of reference of the Committee. The same were discussed in detail and final decision taken.

4. Sub-Committees :—

(*i*) Crop Pattern Sub-Committee :—

It was considered necessary to constitute a Sub-Committee for evolving Crop Patterns for different tracts included in the areas to be irrigated by the Bhakra Canals. Besides this work, the Sub-Committee was also to report on the nature and amount of the artificial fertilizers required, the source from which these should be obtained and the method of their distribution amongst the cultivators. The committee was appointed and following members of the Crop Planning Committee were selected to serve on it :—

1.	Director of Agriculture.	Chairman.
2.	Shri Kapoor Singh, M. L. C.	Member.
3.	Shri Darbara Singh, M. L. A.	,,
4	Shri Gopi Chand Gupta, M. L. A.	,,
5.	Shri Devi Lall, M. L. A.	,,
6.	Master Teg Ram, M.L.A.	,,
7.	Dr. H. L. Uppal, Director, Irrigation & Power Research Institute.	,,

8.	Shri M L. Mehta.	Member
9.	Shri S. D. Kalra, O. S. D. (E).	,,
10.	Secretary Crop Planning Committee, (Convenor)	,,

Director of Agriculture attended one meeting only.

The main work done by this Sub-Committee is the framing of Crop Patterns for the various tracts which has been compiled by Dr. H. L. Uppal as a separate self-contained volume.

(*ii*) Legislation Sub-Committee :—

In view of the facts that the areas to be irrigated by the Bhakra Nangal Project are mostly proprietory and the reclamation of such areas presented a special difficulty during the course of reclamation operation in the Joint Punjab, like using reclamation supplies for irrigating ordinary crops in the adjoining fields, and running of five days Warabandis which are essential for successful reclamation, a Sub-Committee to suggest ways out of the difficulty by Legislation or any other means, was considered necessary and consequently appointed. The following members of the Crop Planning Committee were selected as its members :—

1.	Shri Kapoor Singh, M. L. C.	(Chairman)
2.	Shri Gopi Chand Gupta, M. L. A.	Member.
3	Shri Darbara Singh, M. L. A.	,,
4.	Shri Devi Lall, M. L. A.	,,
5.	Master Teg Ram, M. L. A.	,
6	Director of Agriculture, Punjab.	,,
7.	Shri M. L. Mehta.	,,
8.	Shri S.D. Kalra, O. S. D. (Establishment)	,,
9.	Secretary, Crop Planning Committee, (Convenor).	,,

The main work done by the Sub-Committee is the drafting of 'the Punjab Soil Improvement Bill'.

5. Plan of the Report :—

The Report deals with the terms of reference (reproduced in papagraph 2) as follows :—

Serial No. of term of reference.	Description of the item.	Chapter in which dealt with.
(i)	(a) Most suitable predominant crops and ways and means of obtaining them.	II
	(b) Areas requiring reclamation, technique to be adopted and the organization to be created.	IV
(ii)	To assess changes in the soil as a result of canal irrigation, to study factors operative in bringing about deterioration of the land and the decrease in the yield and to suggest measures to prevent this deterioration.	VII
(iii)	To determine nature and amount of artificial fertilizers required, the source from which to be obtained and the method of distribution amongst the cultivators.	VI
(iv)	To suggest suitable legislation.	V

During the course of the deliberations of the Committee, other important matters connected with Crop Planning and development of Bhakra Canals area have also come to the notice of the Committee. These have been dealt with in chapters III, VIII and IX. Summary and recommendations are briefly given in chapter X and XI respectively.

6. Acknowledgement :—

The Committee wishes to place on record its appreciation of the useful work done by Shri K. S. Malik, the first Secretary of the Committee, in collecting required information, in organizing the work of the Committee which was entirely of a new type. He was succeeded by Shri K. R. Chowdhry who has done valuable work of collecting data and drafting. Amongst the staff of the Irrigation & Power Research Institute who made valuable contribution are Shri Udai Singh Dalal, Land Reclamation Officer who has attended all the meetings of the Committee and Crop Pattern Sub-Committee and Sarvshri C. L. Dhawan, S. R. Sehgal, M. M. L. Malhotra and B. B. Bhatnagar.

The Committee thankfully acknowledges the valuable help given by Dr. Sukh Dyal Nijhawan, Agriculture Department. who spared lot of his time in attending the meetings of the Committee and the Crop Pattern Sub-Committee.

CHAPTER II

CROP PATTERNS

Introduction :—

A pattern is something formed or designed to serve as a guide or model to be copied. It is similar in meaning to the word 'type' which signifies a figure or representation of something to come.

It is universally admitted that, as compared with barani cultivation under well distributed and adequate rainfall, irrigation agriculture is at an economic disadvantage. On the contrary where nature is not bountiful, artificial irrigation is the only means of increasing production of crops. Scientific research has produced varieties of crops, machinery has been devised to till the soil and control weeds, mineral and organic fertilizers have been produced to supplement soil reserves, insects and diseases are being brought under control, and with the construction of dams and reservoirs, the great un-predictable and uncontrollable factor—weather is also being brought under control. But the very water that is a boon to agriculture and supports healthful and prosperous communities may cause distress and impair or destroy, sometimes rapidly, the livelihood of nations and render vast tracts of land infertile if its flow is uncontrolled and it is unwisely used by farmers in the field. Experience of West Punjab is an example. There is no gainsaying the fact that almost all irrigation projects paid heavy dividends and besides food production were responsible for the development of many industries. Cheap construction and injudicious use of canal waters had led to the rise of sub-soil water table, waterlogging and consequent increase in soil salinity and alkalinity in a gradual decrease in soil fertility and also the rapid spread of malaria.

In evolving crop patterns for the areas to be irrigated from the Bhakra Canals the Committee have kept in view the painful experience of the West Punjab and have taken into consideration the fertilizer needs, the machinery required and the most important factor, the drainage. Inside the farm they had foremost in their minds the food, shelter, water and fuel requirements of the farmer; the needs of the livestock for feed and pasture, the market facilities and the prices that may be expected, as also the relative yields of the various crops on the different soils and the needs of the soils for the maintenance of productivity. The blending of all these factors together in a way to maximise farmers' income and comfort was most difficult and has been done rather skilfully by experts from almost all departments of Government.

In laying these patterns it has never been the intention to deprive the cultivator of freedom of action in the exploitation of land. On the contrary these patterns are given as guides so that if he goes astray and impoverishment of his land becomes manifest he can revert back to the ideals laid and save his land from deterioration. It is also hoped that, if at a later date on account of farmers' negligence in sticking to the types and practices laid, state controls are needed, such controls will be more socially acceptable. There is no better way than to quote to the farmer the fate of a builder in the city. The city code requires a builder to limit his structure to a given height, more or less prescribes the the kind of materials he can use and forces him to instal certain devices that allay fire hazards, maintain sanitation standards and make for the general safety of the people who will use the premises. It is just as reasonable to require the owner of a farm to manage his land in such a manner as not to jeopardise the public safety. Under proper controls, the land-owner would have the inalienable right to reap the fruits of his labour and investment.

The patterns that have been evolved and suggested in this report have not been according to chance, but according to a certain end in view. The farmers will be at liberty to make additions and enlargements but it would be essential that all such changes should be in harmony with the initial pattern and the purpose connected therewith.

2. Scientific soil survey of Bhakra Areas :-

In order to know the soil conditions of the area correctly, a complete soil survey of whole of the Project area was carried out. 33,04,200 acres of land spread over 10 tracts lying in Hissar, Karnal, Ambala, Ludhiana, Ferozepore and Jullundur districts was surveyed. A complete report of this survey is available as Appendix B.

About 5 507 profiles each representing 600 acres were taken collecting soil samples from every foot section. As a result of analysis of the soil samples, 23,10,600 acres area was found to be quite fit for carrying out normal cropping but 9,93,600 acres area was found to be impregnated with salinity and alkalinity, right at the surface or at some depth below the surface which would require regular reclamation before putting it under normal cultivation. The tractwise classification is given in table **I**. Plate I shows the tracts.

TABLE I

Showing classification of land surveyed in different tracts of Bhakra Project Area.

Serial No.	Name of District	Name of Tract	Area surveyed as calculated from profiles.	Land fit for normal cropping	Deteriorated Area.
			Acres	**Acres**	**Acres**
1.	Hissar	Rori Chautala	5,55,000	3,48 600	2,06,400
2.	Hissar	Rangoi Tohana	3,83,400	2,16,600	1,66,800
3.	Hissar	South of Sirsa & Fatehabad	3,72,600	3,09,600	63,000
4.	Hissar	Barwala Extension	1,92,600	1,49,400	43 200
5	Hissar	South West of Hissar	72,000	58,200	13,800
6.	Karnal	West of Pehowa	4,82,400	2,73,600	2.08,800
7.	Ludhiana	Khanna Samrala	1,92,600	1,65,600	27,000
8.	Ludhiana	Ludhiana Jagraon	1,75,800	1,51,800	24,000
9A	Ferozepore	Grey Canal	3,97,800	2,16,000	1,81,800
9B	Ferozepore	Muktsar Hithar	69,000	61,200	7,800
10	Jullundur	Bist Doab	4,11 000	3,60,000	51,000
		Total	34,04,200	23,10,600	9,93 600

The brief account incorporating salient features of each of the main tracts is given below : –

(1) Rori Chautala Tract (Hissar District) : –

Total area surveyed of the tract is 5,55,000 acres. Broadly the tract can be divided into three parts. One is comparatively compact and level land on both sides of the River Ghaggar, second is sandy soil with large number of sand dunes scattered all over and the third portion is comparatively lighter soil but level.

In the first part, soil varies from loam to clay loam. Kankar is also found. Normal soil is capable of producing all crops. In the second part the soils are sandy loam but it can give fairly good yields if rains are timely. In the third part crops can be successful with great care as there will be sufficient seepage.

Natural vegetation of the tract is Ak (*Calotropis procera*), Karir (*Capparis aphylla*), Jal (*Salvadora oleoides*), Jand (*Prosopis spicigera*), Chhimber (*Eleusine flagellifera*), Buin (*Kochia indica*), Khip and Bhakhra (*Tribulus terrestris*). Principal salts are sodium sulphate and sodium chloride. Out of 5,55,000 acres, 3,48,600 acres are fit for cultivation directly the water is made available.

(2) Rangoi Tohana Tract (Hissar District) :—

From the point of view of mechanical composition the soil of the tract can be divided into three classes viz. (*i*) Light loam to sandy loam (*ii*) Loam (*iii*) Clay loam to clayey. The majority of area under (*i*) and (*ii*) is being cultivated while type (*iii*) is found on both sides of abandoned Rangoi Canal and is mostly uncultivated. In the cultivated area thick vegetation of Karir (*Cappairs aphylla*), Jand (*Prosopis specigera*), Hins, Ber, Dab (*Eragrostis cynosuroides*) and Chhimber (*Eleusine flagellifera*) are found. Beri, Khabbal (*Cynodon dactylon*), Bhakhra (*Tribulus terrestris*), Dhaman and Lathia are also met.

The water table varies from 18 feet to 120 feet below the natural surface. The quality of soil appears to be good. 2,16,600 acres are fit for normal cropping out of which 11,400 acres are sandy. The sub soil water is saltish and unsuitable for irrigation purposes.

(3) South of Sirsa and Fatehabad Tract (Hissar District) :—

This tract is popularly known as Bagar. Generally the soil is very light and out of 3,72,600 acres surveyed, 10,800 acres are excessively sandy. Sand dunes varying in size and height are also scattered. Some of the tibbas are as high as 30 feet. Chief vegetations are Karir (*Cappairs aphylla*), Jand (*Prosopis specigera*), Chhimber (*Eleusine flagllifera*), Mallah, Kikar (*Acacia arabica*) Beri (*Zizyphus jujube*) and Ducha. The water table of the area varies from 90 to 120 feet. Water is unsuitable for drinking as well as irrigation purposes. Like sandy soils of Rori Chautala tract timely rains are capable of producing good yield of crops. Approximately 54% of the tract is fit for normal cultivation. Predominant salts are sodium sulphate and sodium chloride.

(4) Barwala Extension Tract (Hissar District) :—

Most of the tract is level and cultivated Barani. Soils of this tract are light loam on the surface but lower down they are loamy and appear to be more compact. Kikar (*Acacia arabica*) and Ber (*Ziziphus Jujube*) are the common trees but Khabal (*Cynodon dactylon*), Deela (*Cyperus rotunder*) and Tandla (*Digera arvensis*) also grow wild. Sand Tibbas varying from 15 to 40 feet in height cover approximately 10,000 acres.

In the nature of predominant salts and other characteristics is not different from other tracts of Hissar District. Annual rainfall for the last four years is nearly 14 inches Sub soil water table of the tract varies from 80 to 120 feet. The water is saltish and unsuitable for irrigation purposes. High percentage of salts exists in the form of zones of accumulation. 43,200 acres out of 1,92,600 acres require reclamation and 38,400 acres are excessively sandy.

(5) South West of Hissar Tract (Hissar District) :—

This is the smallest tract covering only 74,803 acres lying south west of Hissar proper. The soil of this tract varies from light loam to sandy loam. Kankar varying in size, shape and colour is found in abundance. At places there are quarries for extraction of Kankar. Natural surface vegetation like Bhakhra (*Tribulus terrestris*), Chhimber (*Eleusine flagellifera*), Khip, Buin (*Kochia indica*) and Kondara *Digera arvensis* are common. Karir *Capparis aphylla*), Kikar (*Acacia arabica*), Jand (*Prosopis specigera*) and Ber (*Jujube*) are the trees met with Near the border of Bikaner District of Rajasthan State sand tibbas varying in height from 10 to 15 feet can be seen. 58,200 acres are fit for normal cropping and 13,800 acres saline and alkaline area will require reclamation. Depth of water table in the wells varies from 80 to 90 feet. Sub soil water being brackish, is unsuitable fo irrigation. Average annual rainfall for the last four years is nearly 14 inches

(6) West of Pehowa Tract (Karnal District) :—

This tract comprises of 4,82,400 acres out of which 2,08,800 acres i.e. approximately 43% area is in different stages of deterioration. The soils are heavier than those of Hissar District. In considerable area high water table already exists. Predominant salts are sodium carbonate and sodium bi-carbonate. Due to the action of these salts soil tilth has become poor. The reclamation of such black alkali soils presents certain complex problems

Normal lands are capable of giving yields. Water table varies from 4 feet to 37 feet. Subsoil water is suitable for irrigation purposes but at places it is saline. Annual rainfall of the district is nearly 25 inches.

Broadly speaking the tract can be sub-divided into three zones. One zone is the rich, fertile land in the Bait areas of Markanda Umla, Jodha etc. Generally the soil of this zone consists of loam to silty loam interspersed with clay loam strips. Second zone is along Saraswati Nadi. Soil is hard, impervious and stiff clay and cracked at the surface. Major portion is covered with thick jungle of Dhak. The third zone comprises of an area which is almost flat and level but is lying uncultivated. A portion of the area is in an advanced stage of deterioration. Here the clay content is high.

(7) Khanna Samrala Tract (Ludhiana District) :—

Soils are indicated to vary between loam and sandy. Trees like Kikar (*Acacia arabica*) and Ber (*Juiuba*) are found. Among ground vegetation Khabbal (*Cynodon dactylon*), Swank (*Pancitum colonmn*). Untchara Panwar (*Cacia tora*), Bhakhra (*Tribulus terrestris*), Kahi and Moth are met with. The depth of soil crust varies from 0 to 8 feet. Excessively sandy soils locally known as Bhudi are put under groundnuts but the yields are not good. Cultivation is almost cent per cent. It appears that soils of Ludhiana district have reached the fatigued stage.

The water table of the area varies from 6 feet to 35 feet and the sub soil water is sweet. Out of 1,92,600 acres surveyed, only 27,000 acres need correctives and the balance land is fit for normal cropping. Annual rainfall in the district is 24 inches.

(8) Ludhiana Jagraon Tract (Ludhiana District) :—

Generally the soil is of light type. Natural vegetations are the same as in Khanna Samrala tract. Total area surveyed of this tract works out to 1,75,800 acres out of which 1,51,800 acres can be directly put under normal cropping. Analysis indicates that inspite of low salt content and low alkalinity, the fertility index of the soil is not upto the mark. Though there may not be big reclamation problem in the tract but restoration of normal fertility requires attention if good yields have to be obtained. Like Khanna Samrala Tract sub-soil water is sweet. Rainfall and water table are as for Khanna Samrala tract.

(9) Grey Canal Tract (Ferozepur District) :—

There are two distinct sub-tracts of this tract. One is Muktsar Hithar area which is more akin to the South of Sirsa and Fatehabad tract Total area surveyed of this sub tract is 69,000 acres out of which 61,200 acres are fit for normal rotation of crops.

Second sub tract is the zone served by a net work of inundation canals known as Grey canals. The canals are non-perennial and supplies are irregular. Total area surveyed of this sub-tract is 3,97,800 acres 2,16,000 acres are fit for normal cultivation. Annual rainfall is approximately 14 inches.

Due to occasional floods, soils near river Sutlej consists of different layers of sand and clay which are deposited by flood water. Water table in this area varies from 0 to 4 feet during winter. Land away from the river is even and generally light loam. Natural vegetations are Dab (*Eragrostis cynosuroides*), Kahi, Sarkanda (*Sadhharum munja*), and ohli (*Carthamus oxyacantha*). Among trees Sheesham (*Dalbergia siscoo*),Mangoes (*Mangifera indica*), Jaman (*Eugenia jambolana*), Mullberry (*Moras serrata*), Ber (*Jujube*), Jal(*Salvadora oleoiaes*) and Kikar (*Acacia-arabica*) are found. This is the worst of all the tracts both as regards salts and waterlogging. Principal salts are sodium sulphate and sodium chloride.

(10) Bist Doab Tract (Jullundur District) : -

The total area in this tract, which has been subjected to scientific soil survey is 4,11,000 acres. The results of analysis indicate that only 51,000 acres out of this is in a state of deterioration and requires reclamation.

The soils of this area belong to the loam and silty type. The annual rainfall is of the order of approximately 20 inches, which is inadequate for obtaining normal yield of crops. In the past Zamindars have made efforts to supplement rainfall with well irrigation. But on account of excessive withdrawls some wells have gone out of action. This tract, therefore, badly stood in need of canal irrigation. It is expected, however, that on the introduction of Canal irrigation the water-table will begin to rise. It is therefore, very necessary to keep a watch on the rise of water-table in this area, so that it does not assume proportions which may threaten the prosperity of the district.

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3. Hydrology of the Area :—

The Punjab enjoys two well-marked seasons of rainfall. Monsoon period lasting from the middle of the June till September and the winter rains which fall early in January and though often insignificant in amount materially affect the prosperity of the Spring harvest. In the sub-montane areas the annual rainfall varies from 25 inches to 35 inches. This shades off to precarious 10 inches towards the Rajasthan border. The Hissar district of the Project area is specially deficient in rainfall and hence this district is frequently visited by famines.

The Bist Doab, Khanna Samrala and West of Pehowa tracts where the spring level is generally 30 to 60 feet below the ground and rainfall is also sufficient have been provided with restricted perennial irrigation supply and hence will not receive water during the months of July and August. This will avoid the danger of waterlogging to which these tracts are liable, besides conserving water for other tracts. The Grey Canal tract comprises riverain areas with high spring level. This has been provided with non-perennial supplies only. The rest of the areas of different tracts comprising Ferozepur and Muktsar tehsils of Ferozepur district, a portion of west of Pehowa tract in Karnal district and Fatehabad, Sirsa and Hansi tehsil of Hissar district where rainfall is scanty, have been provided with perennial supplies.

4. Water requirements of crops :—

In order to benefit to maximum extent from such costly water as will be supplied from Bhakra Project and to reduce the chances of waterlogging to the minimum, it is essential that water requirements of different crops should be taken into account while framing crop patterns for the areas proposed to be irrigated.

The question, therefore, naturally arises as to what is the minimum water requirement of crops for maximum growth and yield. It is also necessary to know the distribution of total water requirements of a particular crop over its total period of existence giving due consideration to rainfall and other climatic factors such as temperature, evaporation, relative humidity, and wind blowing etc. The rainfall over Bhakra Project area varies widely and therefore water requirements of crops will also vary accordingly.

(*i*) *Water requirements in the field* :—Varied data exist about the water requirements of crops in the field. Experiments were carried out in different parts of undivided India. In India, Kennedy was the pioneer in the field of conducting experiments with measured quantities of water and rainfall with regard to differents crops.. Later on Agriculture Department, Punjab, carried out certain experiments on cotton, wheat and toria in 1914-17 and then again at Risalewala near Lyallpur in 1941-47. Irrigation Research Institute, Punjab, also carried out investigations relating to water requirement, during 1928-29. Sind Agriculture Department and Howard of India Agricultural Research Institute Pusa have also, after experimentation, laid down certain quantities of water on which different crops could be matured successfully. D. Milne in collaboration with Ali Mohammad and William Roberts conjointly with Kartar Singh have also recommended the total water requirements and their distribution indicating the number of irrigations for each crop. A summary of work is given in Table II.

Keeping in view local factors, quality of soil, sub soil water table and the existing agricultural practices in different parts of the Punjab [India] and different tracts of Bhakra Project area, none of the figures given in the above mentioned experiments and investigations could be considered as suitable in their entirety because the water requirements arrived at had their basis in local conditions prevailing in those parts of the country at that time. Hence lot of modifications suiting local conditions were inevitable. These modifications were carried out after much thought and deliberations and in doing so broad bases kept in view were the best utilization of water obtaining maximum yields and to avoid as far as possible overlapping between Kharif and Rabi. Finally adopted figures are shown in Table III.

(*ii*) *Water requirements at distributary head* :—Figures given in Table III are the quantities of water which will be actually utilized and therefore must be made available in the field. Considerable seepage losses occur in the water courses and irrigation channels upto distributary head Therefore, the supply which should be made available at channel head should include such losses to ensure the required discharge in the field. It was estimated that 20% supply will be lost in the water courses and 8% in distributaries and min ors. Therefore, to calculate water requirements at distributary head 28% had to be added to the water requirements in the field in case of each and every crop. Table IV shows water requirements at distributary head for each crop in each of the eleven tracts of Bhakra Project area.

(*iii*) *Monthly distribution of water requirements* :—After finalizing the delta required in inches at distributary head for maturing the various crops, the monthly distribution of requirements of water has to be done so that mean discharge at canal head for the month can be worked out. Having calculated monthly water allowance for individual month the supply in the canal can be run accordingly.

Monthly distribution both in the field and at distributary head for different crops in different tracts has been worked out and is given in Table V.

5. **Factors governing Crop Patterns** :—

There are several factors which influence and control the crop pattern of a particular area. The Committee considered all these factors in detail while deciding upon the crop pattern for the individual tracts of land in Bhakra Project area. A few of these factors are discussed below in relation to Irrigation from Bhakra Project.

(*i*) *Water Allowances and Capacity Factors* :—It is more appropriate to fix the water allowance for a particular area on the basis of adopted water requirement of crops, Kharif Rabi ratio and area under each crop in 1,000 acres of culturable commanded area but in the case of Nangal Bhakra Project the water allowance has already been rigidly laid down and the crop patterns have to be devised within this frame-work.

For the purposes of allocating water allowance whole of the area, proposed to be irrigated, has been divided into three types or zones taking rainfall, existing irrigation facilities and depth of water-table into consideration. These zones are :—

(*a*) Restricted perennial,
(*b*) Non-perennial and
(*c*) Perennial.

In restricted perennial zone water-supply will be available for irrigation throughout the year excepting the months of heavy rainfall i.e. July and August. In non-perennial zone the water supply runs during Kharif only and in perennial zone the supply is run for irrigation all the year round.

TABLE

Studies regarding water

Serial No.	Reference to Experiment or locality	Description of crops		
		Wheat	Cotton	Sugar cane
		Depth of watering in inches in field		
1	Experiments near Lyallpur Punjab	17.5	34	78
2	Punjab Irrigation Research Institute.	12‡	20‡	40‡
3	Agricultural Research Institute, Pusa.	7—10‡	...	...
4	Punjab.	10—13‡	...	...
5	Punjab	10—13‡	...	40—49‡
6	Punjab	12	22‡	50—60 (—rain)
7	Agriculture Department Sind	14·4	37.2	...
8	Southern San Joa quin valley California, U.S.A.	36—44‡	...	...
9	U. S. A. (South West)	18—27	28—42	42—55
10	U. S. A. Eastern Texas	...	30	...
11	Masilla Valley New Mexico, U. S. A.	...	18—24‡	...
12	Western Nebraska, U. S. A.	22	...	...
13	Missouri & Arkansas River Basin, U. S. A.	16—22	...	...
14	U. S. A. South West	18—27	28—42	42—55

‡Exclusive of rain.

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II

requirements of various crops.

Rice	Oil Seeds	REFERENCE
...	7·5 for Toria	"Water requirements of crops under canal irrigated conditions" Department of Agriculture, East Punjab, Leaflet No. 4 (1948).
40‡	...	"An analysis of the utilization of Irrigation water in Typical Punjab Canals"Memoires of the Punjab Irrigation Research Laboratory, Vol. III No. 1.
...	...	‡The Saving of Irrigation Water in wheat growing" Agricultural Research Institute, Pusa Bulletin No. 118, 1921.
...	...	"No. of Waterings required for wheat crop" Punjab Irrigation Branch Paper III—C by Mr. Kennedy.
50 (—rain)	7‡ For Toria	"A Hand Book on Field and Garden Crops of the Punjab" by D. Milne and Ali Mohammad.
60	...	"A Text Book of Punjab Agriculture" by William Roberts and Kartar Singh.
...	...	"An Investigation of the water requirements of Crops"by Tamhane Iyenger and Chandani. "Current Science Volume VI No. 6 December, 1947.
...	...	"Water requirements of cotton on Sandy Loam Soils in Southern San Joaquin Valley, University of California Bulletin No. 537, page 44.
...	...	"Irrigation requirements of the Arid and Semi-arid lands of the south west" page 29 of Technical Bulletin No. 185 June, 1930, U. S. Department of Agriculture.
...	...	"Irrigation Engineering" Vol. 1 by Ivon E. Houk—John Wiley and Sons. (Page 352)
...	...	—do—
...	...	—do—(p. 353)
...	...	—do—(p. 355
...	...	—do—

Table III

Showing adopted water requirements of each crop in inches in the field for different tracts of Bhakhra Project area.

Serial No.	Name of tract	Wheat inches	Cotton inches	Sugar cane inches	Rice inches	Oil Seeds inches	Ground-nut inches	Kharif fodders inches	Rabi fodders		Other Food grains		Orchards and vegetables	
									Berseem inches	Others inches	Kharif inches	Rabi inches	Kharif inches	Rabi inches
1.	Rori Chautala. ...	14·4	35	65	60	11·5	...	14	50	16	13	8·5	40	40
2.	Rangoi Tohana. ...	14·4	35	65	60	11·5	...	14	50	16	13	8·5	40	40
3.	South of Sirsa & Fatehabad	14·4	35	65	60	11·5	...	14	50	16	13	8·5	40	40
4.	Barwala Extension. ...	14·4	35	65	...	11·5	...	14	50	16	13	8·5	40	40
5.	South West of Hissar. ...	14·4	35	65	...	11·5	...	14	50	16	13	8·5	40	40
6.	West of Pehowa. ...	14	22	50	50	9	...	12	50	15	7	7	30	30
7.	Khanna Samrala. ...	13	22	54	...	10	13	13	50	16	13	8·5	40	40
8.	Ludhiana Jagraon or Sidhwan Branch. ...	13‡	25	40	60	10‡	13	13‡	50‡	15	13	8·5‡	40	20‡
9A.	Grey Canal tract (excluding Muktsar Hithar area).	13‡	25	40	60	10‡	...	13	50‡	16‡	13	8·5‡	40	20‡
9B.	Muktsar Hithar area. ...	14·4	35	65	60	11·5	...	14	50	16	13	8·5	40	40
10.	Bist Doab. ...	13	20	52	...	10	...	13	50	16	13	8·5	40	40

‡In actual working at sight only 4 inches of water will be available during October. In crop patterns only 4 inches for each crop have been accounted for.

Table IV

Showing adopted water requirements of each crop at distributary head for different tracts of Bhakhra Project Area.

Serial No.	Name of tract	Wheat inches	Cotton inches	Sugar cane inches	Rice inches	Oil Seeds inches	Ground-nut inches	Kharif fodders inches	Rabi fodders		Other Food grains		Orchards and vegetables	
									Berseem inches	Others inches	Kharif inches	Rabi inches	Kharif inches	Rabi inches
1.	Rori Chautala. ...	18·43	44·8	83·2	76·8	14·72	...	17·92	64·0	20·5	16·64	10·88	51·2	51·2
2.	Rangoi Tohana. ...	18·43	44·8	83·2	76·8	14·72	...	17·92	64·0	20·5	16·64	10·88	51·2	51·2
3.	South of Sirsa & Fatehabad	18·43	44·8	83·2	76·8	14·72	...	17·92	64·0	20·5	16·64	10·88	51·2	51·2
4.	Barwala Extension. ...	18·43	44·8	83·2	...	14·72	...	17·92	64·0	20·5	16·64	10·88	51·2	51·2
5.	South West of Hissar. ...	18·43	44·8	83·2	...	14·72	...	17·92	64·0	20·5	16·64	10·88	51·2	51·2
6.	West of Pehowa. ...	17·92	28·16	64·0	64·0	11·41	...	15·36	64·0	20·5	8·96	8·96	38·4	38·4
7.	Khanna Samrala. ...	16·64	28·16	69·12	...	12·8	16·64	16·64	64·0	20·5	16·64	10·88	51·2	51·2
8.	Ludhiana Jagraon or Sidhwan Branch. ...	16·64	32·0	51·0	76·8	12·8	16·64	16·64	64·0	20·5	16·64	10·88	51·2	25·6
9A.	Grey Canal tract (excluding Muktsar Hithar area).	16·64	32-0	51·2	76·8	12·8	...	16·64	64·0	20·5	16·64	10·88	51·2	25·6
9B.	Muktsar Hithar area. ...	18·43	44·8	83·2	76·8	14·72	...	17·92	64·0	20·5	16·64	10·88	51·2	51·2
10.	Bist Doab. ...	16·64	25·6	66·56	...	12·8	...	16·64	64·0	20·5	16·64	10·86	51-2	51·2

(*a*) *Restricted perennial* :—In the restricted perennial zone are included the areas to be irrigated in Samrala tehsil of Ludhiana district, Phillaur, Nawanshahr and Nakodar tehsils of Jullundur district, some portion of Kaithal tehsil of Karnal district and Rupar tehsil of Ambala district. Total area proposed for annual irrigation is 4,94,161 acres out of 10,98,138 acres of the culturable commanded area. Water allowance fixed for this zone is 2·25 cusecs per 1,000 acres of C.C.A. at distributary head. The prescribed capacity factors and full supply days are as follows :—

S No.	*Month*	*Capacity factors*	*Full supply days*
		Kharif	
1.	April	0·33	10·00
2	May	0·75	23·25
3.	June	0·75	22·50
4.	July	Closed	—
5.	August	Closed	—
6.	September	0·75	22·50
	Total Kharif	0·43	78·25
		Rabi	
7.	October	0·90	27·90
8.	November	0·90	27 90
9.	December		
	1—15	0·50	7 50
	16—31	0·33	5·33
10.	January		
	1—15	0·33	5·00
	16—31	0·50	8 00
11.	February	0·75	21·00
12.	March	0·76	23·25
	Total Rabi	0·69	1 4·98

Therefore Total full supply days in the year. =203·2

(*b*) *Non perennial* :—Non perennial supply will be given only to the areas lying in Zira tahsil of Ferozepur district which receive irrigation at present from Grey Canals, known as Grey Canal tract excepting Muktsar Hithar sub-tract, and those lying in Jagraon and

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Ludhiana tahsils of Ludhiana district, which has been mentioned as Ludhiana Jagraon or Sidhwan Branch tract under the head Scientific Soil Survey. Total area which is proposed for annual irrigation works out to 1,72,536 acres out of 4,92,961 acres of C. C. A.

The water allowance laid down is 3·5 cusecs per 1,000 acres of C. C. A. at the distributary head. Below are given the proposed capacity factors and full supply days for this zone. In this zone some irrigation has been allowed during the month of October for maturing late Kharif crops and sowing Rabi crops.

S. No.	*Month*	*Capacity Factor*	*Full supply days*
1.	May	0·80	24·80
2.	June	0·95	28·50
3.	July	0·80	24·80
4.	August	0·80	24·80
5.	September	0·90	27·00
6.	October	0·90	27·90
		Total	157·80

(*c*) *Perennials* :—Areas included in this zone belong to Ferozepur and Muktsar tehsils of Ferozepur district, a portion of West of Pehowa tract in Karnal district and in Fatehabad, Sirsa, Hissar and Hansi tehsil of Hissar district.

All the five tracts lying in Hissar district fall in the perennial zone for which water allowance is 2·75 cusecs per 1,000 C. C. A. at distributary head. Total area covered is 14,02,752 acres out of total C. C. A. of 22,62,504 acres. The prescribed capacity factors and full supply days for the zone are shown in the following table.

S. No.	*Month*	*Capacity Factors Kharif*	*Full supply days*
1.	April	0·50	15·0
2.	May	0·90	27·9
3.	June	0·90	27·0
4.	July	0·80	24·8
5.	August	0·80	24·8
6.	September	0·90	27·0
		Total	**146·5**
	Mean Kharif	0·80	**24·4**

		Rabi	
7.	October	0·90	27·9
8.	November	09·0	27·0
9.	December		
	1—10	0·90	9·0
	11—31	0·60	10·5
10.	January	0.50	15.5
11.	February		
	1—10	0.50	6.9
	11—28	0·75	13.5
12.	March	0·75	23.3
	Total		131.7
	Mean Rabi	0.72	21.8

Therefore total full supply days in the year = 278.2

(*ii*) *Intensity of Irrigation*: It is defined as area proposed to be irrigated during the year per 100 acres of culturable commanded area on a particular channel. While on an irrigation project it is prescribed on the basis of practice in vogue on existing channels, it is not a very rigid thing and goes on changing in actual practice with the passage of time according to the increasing needs of the Zamindars. But for evolving crop patterns some figure has to be taken as the basis for calculations. For the Bhakra Project area it has been laid down as given below :—

S. No.	*Type of irrigation*	*Intensity*
1.	Perennial	62%
2.	Restricted perennial	45%
3.	Non-perennial	35%

(*iii*) *Kharif Rabi Ratio* :—It is a very important factor for determining the quantities of water required in a particular channel during the two crop seasons and distribution of the proposed area for cropping under different kinds of crops.

Soil survey of the area has brought out that the lands are in general like those met with in irrigation colonies on Lower Chenab and Lower Bari Doab Canals of Joint Punjab. Therefore, it was considered that Kharif Rabi ratio obtained on those canals (Table VI) would be quite suitable for perennial and restricted perennial zones of the Bhakra Project area. For these zones it has been adopted as 1 : 1·25 or 4 : 5.

The non-perennial zone, as already stated includes areas lying in Ferozepur district. On Eastern Canal, which also irrigates this district, the water supply is non-perennial and the existing Kharif Rabi ratio is 52 : 48. It was, therefore, decided to adopt the same ratio for areas included in non-perennial zone on Bhakra Canals.

(*iv*) *Size of Holding and Family Members* :—The number of family members and the size of their holding have always been the controlling factors in adjusting the requirements of every farmer with regard to each kind of crop. The primary needs of his family play a major part in determining the most suitable crop pattern.

There are only a few big landlords in Punjab (India). In general the holding of an average Zamindar is small. For the purposes of designing crop patterns an average holding has been taken to be of 12·5 acres and 4·5 members have been supposed to constitute a family. The size of holding smaller than 12·5 acres usually becomes an uneconomical unit and cannot be considered as standard.

The above standards have been adopted for all the tracts irrespective of the type of irrigation proposed to be introduced.

(v) *Quality of soil* :—The mechanical composition and texture of soil play an effective role in selecting the kind of crops which will be successful in a particular land. For example ground-nut will be very successful in lighter soils known as Bhudi in Khanna Samrala and Ludhiana Jagraon district, rice will give better yields in Rangoi Tohana tract, West of Pehowa tract, Grey canal tract and Ludhiana Jagraon tract, sugarcane can be put on much larger area in Bist Doab tract and cotton will flourish comparatively much better in South of Sirsa and Fatehabad tract, Rori Chautala tract and Muktsar Hithar Sub tract in Ferozepur district.

(vi) *Sub-Soil Water Table* :—It is well known that the sub-soil water table has a great influence on the moisture gradient of the profile above it. The nearer it is to the natural surface the more pronounced this influence will be. In other words more moisture will be available in the soil in waterlogged area than in deep water table lands. The more the moisture near the root zone of crops, the less will be their water table lands. The more the moisture near the root zone of crops, the less will be their water requirements. Consequently comparatively larger areas can be put under cropping with a particular quantity of irrigation supply in high water-table soils.

TABLE

Showing monthly distribution of water requirements in inches

KHARIF

S. No.	Crop	Name of tract	Supply at	January	February	March
1	2	3	4	5	6	7
1.	Kharif Fodders	West of Pehowa.	Field	...	...	...
			Disty. Head	...	...	...
		Khanna Samrala	Field	...	...	...
		Bist Doab.	Disty. Head	...	...	...
		Grey Canal & Sidhwan Branch.	Field	...	...	...
			Disty. Head	...	...	...
		Other Tracts.	Field	...	...	...
			Disty. Head	...	...	...
2.	Other Food Grains Kharif	West of Pehowa.	Field	...	...	...
			Disty. Head	...	...	...
		Khanna Samrala	Field	...	...	...
		Bist Doab	Disty. Head	...	...	..
		Other tracts	Field	...	...	...
			Disty. Head	...	...	...
3.	Sugar cane	West of Pehowa	Field	1·25	2·0	4·25
			Disty. Head	1·60	2·56	5·44
		Khanna Samrala.	Field	1·25	2·0	4·25
			Disty. Head	1·60	2·56	5·44
		Bist Doab	Field	1·25	2·0	4·25
			Disty. Head	1·60	2·56	5·44
		Grey Canal & Ludhiana Jagraon	Field	...	...	...
			Disty. Head	...	...	...
		Other tracts.	Field	1·0	3·0	3·0
			Disty. Head	1·28	3·84	3·84
4.	Cotton	West of Pehowa &	Field	...	...	...
		Khanna Samrala.	Disty. Head	...	...	...
		Bist Doab.	Field	...	...	...
			Disty. Head	...	...	...
		Grey Canal & Ludhiana Jagraon.	Field	...	...	...
			Disty. Head	...	...	...
		Other Tracts.	Field	...	...	1·44
			Disty. Head	...	...	1·85
5.	Rice	West of Pehowa.	Field	...	...	...
			Disty. Head	...	...	...
		Rangoi Tohana.	Field	...	...	...
		Rori Chautala, South of Sirsa and Fatehabad Muktsar Hithar, Grey Canal & Ludhiana Jagroan.	Disty. Head	...	...	...
6.	Ground-nut	Khanna Samrala & Ludiana Jagraon.	Field	...	...	...
			Disty. Head	...	...	...

V

of each crop for different tracts of Bhakra Project Area

April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Total
8	9	10	11	12	13	14	15	16	17
1·5	4·0	5·0	...	...	1·5	...	...	...	12·0
1·92	5·12	6·4	...	...	1·92	...	...	...	15·36
1·5	4·5	5·0	...	...	2·0	...	...	...	13·0
2·56	5·12	6·4	...	...	2·56	...	...	...	16·64
0·88	2·87	4·19	3·08	0·66	1·32	...	...	...	13·0
1·13	3·67	5·36	3·95	0·84	1·69	...	...	...	16·64
1·38	3·37	4·19	3·08	0·66	1·32	...	...	...	14 0
1·77	4·31	5·36	3·95	0·84	1 69	...	...	...	17·92
...	...	3·0	...	...	3·0	1·0	...	...	7·0
...	...	3·84	...	...	3·84	1·28	...	...	8·96
...	3.0	3·0	...	...	5·0	2·0	...	...	13·0
...	3·84	3·84	...	...	6·4	2·56	...	...	16·64
...	...	...	3·0	3·0	5·0	2.0	...	...	13·0
...	...	...	3·84	3·84	6·4	2·55	...	...	16·64
8·0	8·5	8·5	...	...	5·5	4·0	4·0	4·0	50·0
10·24	1·088	10·88	...	...	7·04	5·12	5·12	5·12	64·0
8·5	10·0	10·0	...	...	6·7	4·0	4·0	4·0	54 0
10·88	12·8	12·8	...	...	7 68	5·12	5·12	5·12	69·12
8·0	9·5	9·5	...	...	5·5	4·0	4·0	4·0	52·0
10·24	12·16	12·16	...	...	7·04	5·12	5·12	5·12	66·56
1·0	9·0	10·0	5·0	5·0	6·0	4·0	...	...	40·0
1·28	11·52	12·8	6·4	6·4	7 68	5 12	...	...	51·2
8·0	10·0	10·0	6·0	6·0	7·0	4·0	3·5	3·5	65·0
10·24	12·8	12·8	7 68	7 68	8·96	5 12	4·48	4 48	83·2
3·61	3·78	5·48	...	...	5·42	3·71	...	...	22·0
4·58	4·85	7·02	...	...	6·95	4·76	...	...	28·16
3·2	3·78	5 0	...	...	4·81	3 21	...	...	20·0
4·1	4·85	6·4	...	...	6·16	4·11	...	...	25·6
...	3·78	6·05	3·0	3·78	5·19	3·21	...	...	25·0
...	4·85	7·74	3·85	4·85	6·64	4·11	...	...	32·0
3·46	4·43	6·94	5·0	4·7	5·57	3·46	...	...	35·0
4·43	5·68	8·25	6·4	6·02	7·13	4·43	...	...	44·8
...	10·0	17·0	...	...	14·0	8·0	1 0	...	50·0
...	12 8	21·76	...	...	17·92	10·24	1·28	...	64·0
...	1·0	9·0	13·0	14·0	14·0	7·0	2·0	...	60·0
...	1·28	11·52	16 64	17·92	17·92	8·96	2·56	...	76·8
...	4·0	3·0	...	...					13·0
...	5·12	3·84	...	...					16·64

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TABLE

Showing monthly distribution of wate. requirements in inches

Sr. No.	Crop	Name of Tract	Supply at	January	February	March
1	2	3	4	5	6	7
						RABI
7.	Berseem	All tracts except Grey Canal and Ludhiana Jagraon	Field	5·0	5·0	8·0
			Disty. Head	6·4	6·4	10·24
8.	Other Rabi Fodders	Grey Canal & Ludhiana Jagraon	Field	...	...	...
			Disty. Head	...	...	...
		Other Tracts	Field	2·0	2·0	...
			Disty. Head	2·56	2·56	...
9.	Oilseeds	West of Pehowa	Field	...	1·5	0·5
			Disty. Head	...	1·92	0·64
		Khanna Samrala & Bist Doab.	Field	1·0	1·5	0·5
			Disty. Head	1·28	1·92	0·64
		Grey Canal & Ludhiana Jagraon	Field	...	...	...
			Disty. Head	...	...	...
		Other Tracts.	Field	1·0	1·5	0·5
			Disty. Head	1·28	1·92	0·64
10.	Wheat.	West of Pehowa	Field	1·23	2·30	2·98
			Disty. Head	1·57	2·87	3·77
		Khanna Samrala & Bist Doab.	Field	1·10	2·0	2·95
			Disty. Head	1·41	2·56	3·78
		Grey Canal & Ludhiana Jagraon.	Field	...	...	...
			Disty. Head	...	...	...
		Other Tracts.	Field	1·27	2·23	3·18
			Disty. Head	1·57	2·85	4·07
11.	Other Food Grains Rabi	West of Pehowa.	Field	...	...	...
			Disty. Head	...	...	...
		Grey Canal & Ludhiana Jagraon	Field	...	...	...
			Disty. Head	...	...	...
		Other Tracts.	Field	...	...	...
			Disty. Head	...	...	...
						MISCELLANE
12.	Orchards and Vegetables.	West of Pehowa.	Field	5·0	5·0	5·0
			Disty. Head	6·4	6·4	6·4
		Khanna Samrala & Bist Doab.	Field	6·5	6·5	6·5
			Disty. Head	8·32	8·32	8·32
		Grey Canal & Ludhiana Jagraon.	Field	...	...	
			Disty. Head	...		...
		Other Tracts.	Field	6·67	6·67	6·67
			Disty. Head	8·53	8·53	8·53

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V (*contd.*)

of each crop for different tracts of Bhakra Project Area.

April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Total
8	9	10	11	12	13	14	15	15	17
9·0	3·0	...	...	...	1·0	7·0	7·0	5·0	50·0
10·24	3·84	...	...	...	1·28	8·96	8·96	6·4	64·0
...	...	...	...	...	...	4·0	...	...	4·0
...	...	...	...	...	...	5·12	...	...	5·12
...	...	..	..	...	2·5	4·0	3·5	2·0	16·0
...	...	...	...	...	3·2	5·12	4·43	2·56	20·48
...	...	...	...	...	2·0	2·0	1·5	1·5	9·0
...	...	...	...	...	2·56	2·56	1·92	1·92	11 52
...	..	...	...	...	2·0	2·0	1·5	1·5	10·0
...	...	...	...	...	2·56	2·56	1·92	1·92	12·8
...	...	...	...	...	2·0	2·0	...	...	4·0
...	...	...	...	...	2·56	2·56	...	...	5·12
...	...	...	...	..	2·5	2·5	1·75	1·75	11·5
...	...	...	...	...	3·2	3·2	2·24	2·24	14·72
1·0	...	...	...	...	1·01	2 40	1·34	1·74	14·0
1·28	...	...	...	...	1·29	3·0	1·72	2·30	17·92
1·05	...	...	...	...	0·9	2·15	1·20	1·65	13·0
1·34	...	...	...	...	1·15	2·75	1·54	2·11	16·64
...	...	...	...	...	1·5	2·5	...	...	4·0
...	...	...	...	...	1·92	3·2	...	...	5·12
1·17	...	...	...	...	1·01	2·40	1·34	1·84	14·4
1 50	...	...	...	...	1·29	3·07	1·72	2·36	18·43
...	...	...	...	...	...	4·0	...	3·0	7 0
...	...	...	...	...	...	5·12	...	3·84	8·96
...	...	...	...	...	...	4·0	...	...	4·0
...	...	...	...	...		5·12	...	...	5·12
...	...	...	...	...	1·5	4·0	...	3·0	8·5
...	...	...	...	...	1·92	5·12	...	3·84	10·88
OUS									
7 5	7 5	7·5	...	—	7·5	5·0	5·0	5·0	60·0
9·6	9·6	9·6	...	...	9·6	6·4	6·4	6·4	76·8
10·0	10·0	10 0	...	...	10·0	8·5	6·5	6·5	80·0
12 8	12·8	12·8	...	...	12·8	9·6	8·32	8·32	102·4
...	8·0	8 0	8·0	8·0	8·0	4·0	...	...	44·0
..	10 24	10·24	10 24	10·24	10·24	5·12	...	...	56·32
6·67	6 67	6·67	6·67	6·67	6 67	6 67	6·67	6·67	80·0
8 53	8·53	8·53	8·53	8·53	8·53	8·53	8·53	8·53	102·4

TABLE

Crop Pattern Statement of Canals of the

No.	Name of Canal	Area irrigated	RABI Wheat		Oil Seeds	
		Areas	Areas	%	Areas	%
1	2	3	4	5	6	7
	PERENNIAL				INDIAN CANALS	
1	Western Jumna Canal	986910	252416	25	14649	2·0
2.	Upper Bari Doab Canal	763188	89121	12	35394	4·6
3.	Sirhind Canal (Pb.)	1376428	443385	32	30206	2·2
4.	Sirhind Canal (Pepsu)	701514	241295	34	2498	0·4
5.	Gang Canal	561196	27849	4·9	46066	8·2
	NON-PERENNIAL					
6.	Eastern Canal.	155715	19713	13	2553	1·6
	INUNDATION					
7.	Sarasti Canal	33378	1748	5·2	160	0·5
8.	Gaggar Canal (Punjab)	16774	1168	7·0	1181	7·1
9.	Gaggar Canal (Rajasthan)	11665	309	2·7	632	5·4

Note:—There is a difference of 3166 between the total area irrigated
Kharif. The difference is due to approximation in figures
discharge at head of U. B. D. C. while Kharif and Rabi discharges

No.	Name of Canal	Area irrigated	Wheat Areas	%	Oil Seeds Areas	%
	PERENNIAL				PAKISTAN CANALS	
1.	Upper Bari Doab Canal	544761	74404	14	29649	5·4
2.	Lower Bari Doab Canal	1341564	420363	31	40828	3·0
3.	Upper Chenab Canal	662973	147980	20	15399	2·4
4.	Lower Chenab Canal	2649408	281940	37	105679	4·0
5.	Upper Jhelum Canal	347757	100493	29	5472	1·5
6.	Lower Jhelum Canal	934452	325548	35	16232	1·7
7.	Pak-Patan Canal	744565	258054	35	25674	3·4
8.	Haveli Canal	723098	263609	36	15665	2·2
	NON-PERENNIAL					
9.	Mailsi Canal	359341	116758	33	31940	8·8
10.	Dipalpur Canal	515003	101778	20	4458	0·9
11.	Rangpur Canal	112835	40399	38	1224	1·1
	INUNDATION					
12.	Mozaffargarh Canal	298910	136242	45	4977	1·7
13.	Indus Canal	242213	89203	37	2847	1·2
14.	Shahpur Canal	68872	20033	29	151	0·2
	PERENNIAL	SIND				
15	Rohri Canal	1081083	407405	38	16196	1·5
16.	Eastern Nars Canal	964394	333063	35	6583	0·7
17.	North-Western Canal	492491	141565	29	60872	12
18.	Dadu Canal	250728	85056	34	11280	45
	NON-PERENNIAL					
19.	Rice Canal	489679	19049	3·9	24747	5·1
20.	Manchar Drainage	16480	9770	59	2151	13
21.	N.E. Grey E. Siddiqias, Quian, Bahawal, Abbassi and Panjnad (Bahawalpur District)	1221554	176289	14	147813	12
22.	Bahawal Abbassia and Panjnad (Rahimyarkhan District)	893427	271139	30	96549	11

Note:—See note below Indian Canals. That holds good in case of Pakistan Canals as well.

VI

Indus Basin, Average for 1941-42 to 1945-46.

Other food grains		Miscellaneous including fodder		Total Rabi		Rice	
Areas	%	Areas	%	Areas	%	Areas	%
8	9	10	11	12	13	14	15
217193	22	55710	6·0	539967	55	24775	3·0
142715	9	72866	9·5	340096	45	42521	5·5
158048	12	40855	3·0	572494	49	158	0·1
53782	7·7	46460	6·6	344035	49	4792	0·7
202336	36	16665	3·0	292916	52	4032	0·7
49527	31	3538	2·3	75329	48	9776	6·3
17391	32	3567	11	22866	68	4403	13
7378	44	750	4·5	10477	62	3449	20
3896	33	328	2·8	3165	44	...	...

and the summation of totals of irrigation during Rabi and for U B.D C. where total discharge utilized in India is 58·35% bear percentages equal to 61·4% and 54·5 respectively.

PUNJAB

119148	22	60833	11	283934	52	26731	4·9
82549	6·2	161978	12	705718	53	32612	2·4
25884	8·9	59885	9·0	249158	38	299149	45
1 8294	4·5	297351	11·0	1503271	57	191913	3·5
17428	5·0	60438	17	183831	53	23803	6·9
71320	7·7	130016	14	543116	58	11256	1·2
35369	4·7	52493	7·0	371590	50	8509	1·1
36884	5·1	87724	12·0	403850	56	9329	1·3
20428	5·6	5252	1·5	174378	48	521	0·1
81371	16	44981	8·7	232588	45	51743	10
8928	8·0	12952	11	63503	56	4816	4·3
31604	11	11124	3·7	183947	62	15329	5·1
31854	13	7390	3·1	131294	54	36368	15
5749	8·3	12095	18	38028	55	8830	3·3
2491	0·2	38228	3·5	464320	43	6062	0·6
812	0·1	18681	1·9	359739	37	85811	9·0
512	0·1	75385	15	278334	57	124601	26
2167	0·9	31427	13	129930	52	481305	19
264	0.1	132001	27	176048	30	6856	62
209	1·3	793	4·8	12923	78	123	7·5
326349	27	100455	9·0	750906	61	21077	1·7
36506	4·1	30922	3·5	435107	49	24463	2·7

TABLE

Crop Pattern Statement of Canals of the

No.	Name of Canal	KHARIF			
		Other Food-grains		Sugarcane	
		Areas	%	Areas	%
1	2	16	17	18	19
	PERENNIAL				
1.	Western Jumna Canal	110722	11	54829	6·0
2.	Upper Bari Doab Canal	93109	12	24290	3·1
3.	Sirhind Canal (Pb.)	277462	20	11999	0·9
4.	Sirhind Canal (Pepsu)	201513	29	13913	2·0
5.	Gang Canal	159351	28	8621	1·5
	NON-PERENNIAL				
6.	Eastern Canal	31033	20	5015	32
	INUNDATION				
7.	Sarasti Canal	2487	7·3	86	0·3
8.	Gaggar Canal (Pepsu)	1772	11	...	...
9.	Gaggar Canal (Rajasthan)	2793	26	...	...
1.	Upper Bari Doab Canal	58534	11	15271	2·8
2.	Lower Bari Doab Canal	147793	11	19367	1·4
3.	Upper Chenab Canal	31605	4·8	9697	1·6
4.	Lower Chenab Canal	261710	10	68764	2·6
5.	Upper Jhelum Canal	41967	12	9558	2·7
6.	Lower Jhelum Canal	114553	12	12447	1·3
7.	Pak-Patan Canal	61306	8·2	4125	0·6
8.	Haveli Canal	33570	4·6	5551	0·8
	NON-PERENNIAL				
9.	Mailsi Canal	54053	15	690	0·1
10.	Dipalpur Canal	78030	15	8412	1·6
11.	Rangpur Canal	5351	4·7	1937	1·7
	INUNDATION				
12.	Mozaffargarh Canal	18289	6·1	5070	1·7
13.	Indus Canal	17219	7·2	2299	1·0
14.	Shahpur Canal	4082	5·9	371	0·5
	PERENNIAL				
15	Rohri Canal	158687	15	1134	0·1
16.	Eastern Nars Canal	75093	7·8	3423	0·4
17.	North Western Canal	75451	15	37	...
18.	Dadu Canal	38929	15	126	0·1
	NON-PERENNIAL				
19.	Rice Canal	5914	1·2	20	...
20.	Manchar Drainage	2101	13	1	...
21.	N E.Grey E.Siddiqias, Quian, Bahawal, Abbassi and Panjnad (Bahawalpur District)	143692	12	19645	1·6
22.	Bahawal (Abbassia and Panjnad (Rahimyarkhan Distt.)	82597	9·3	7546	0·8

VI (Concld).

Indus Basin, Average for 1941-42 to 1945-46.

Cotton		Miscellaneous including Fodder		Total Kharif	
Areas	%	Areas	%	Areas	%
20	21	22	23	24	25
148730	15	107889	11	446943	46
101137	13	138869	21	419986	55
174210	13	240105	17	703934	51
108834	16	28367	4·0	357478	51
29877	5·3	66399	12	268280	48
9997	6·4	24565	16	80386	52
361	1·1	3205	9·6	10512	32
...	...	1078	6·4	6297	38
2	...	3700	32	5600	36
63582	12	99875	17	263993	48
240809	18	195265	15	635844	47
24208	3·8	39167	7·4	413826	62
484181	18	239579	9·1	1144137	43
60456	18	28142	8·1	163926	47
173244	19	79836	8·5	399336	42
224867	30	74168	10	372975	50
188746	22	112051	16	519248	44
65910	18	63989	18	184963	52
74187	14	70043	14	282415	55
12407	11	24821	22	49232	44
17004	5·7	59271	20	114963	33
10554	4·4	44479	18	110919	46
13664	20	10397	15	36844	45
413439	38	37421	3·8	616763	57
417639	43	23289	2·4	605255	63
7992	2·0	6076	1·2	214157	43
29584	12	3854	1·8	120798	48
279	0·1	1533	0·3	313638	64
35	0·2	190	1·2	3557	22
148819	12	137415	11	470648	39
225028	25	118687	13	458320	51

Due condideration has, therefore, to be given to this factor while fixing water requirements and percentage of cropped area for different tracts of the State.

(vii *Area proposed under each crop* :—Having known the Kharif Rabi ratio and intensity of irrigation it is essential to distribute the area proposed to be cropped in the individual holding over each crop which is planned to be taken according to the needs of the Zamindars. Variations in percentages of area under each crop are bound to occur in different tracts because of difference in climatic and other soil conditions.

The grain or cereal requirements are governed by the number of family members and cattle heads. Fodders produced should be sufficient for the cattle, which will be needed for farming and to meet the requirements of milk butter, cheese etc., etc. Area under sugarcane is controlled by the capacity of Zamindar to manage it profitably and other cash crops depend upon his other primary needs which he has to fulfil by making purchases in cash. The basic idea in fixing areas under different crops is to enable the Zamindar to become economically self-sufficient. This has also to be adjusted within the limits of permissible water allowance. Of course existing practices can also serve as some guide in this respect.

The distribution of the cropped area in 1000 areas of C. C. A. under each crop in different tracts of Bhakra Project area is given in Table VII.

(viii) *Water requirements of crops* :—This has already been dealt with under para 3.

6. Method of Evolving Crop Patterns :—

(i) *Annual Water Allowance :*—First of all Kharif Rabi ratio and intensity of cropping is laid down for a particular tract Then the percentages of area under each crop in a specified average holding are worked out in accordance with the given Kharif Rabi ratio and intensity of irrigation. Having known the water requirements of each crop in the field, it is quite simple to calculate areas under different crops in 1000 acres of culturable commanded area and water requirements of individual crop at the distributary head keeping the Kharif Rabi ratio and intensity of cropping undisturbed.

The product of cropped area under a particular crop in 1000 acres of C. C. A. and its water requirements in inches at dis-

TABLE NO. VII

Showing area proposed under each crop in different tracts of Bhakra Project area per 1,000 acres of C. C. A.

S. No.	Name of Tract	Kharif Crops								Rabi Crops						Total Rabi and Kharif
		Kharif fodder	Sugarcane	Cotton	Rice	Other food-grains	Groundnut	Orchard & vegetables	Total Kharif	Rabi fodder	Wheat	Other food-grains	Oil-seeds	Orchards and vegetables	Total	
		Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
1.	Rori Chautal	87	10	148	...	24	...	6	275	62	217	35	25	6	345	620
2.	Rangoi Tohana	87	15	87	30	50	...	6	275	62	217	35	25	6	345	620
3.	South of Sirsa	87	10	148	...	24	...	6	275	62	217	35	25	6	345	620
4.	Barwala Extension	87	15	136	...	31	...	6	275	62	217	35	25	6	345	620
5.	South West of Hissar	87	15	136	...	31	...	6	275	62	217	35	25	6	345	620
6.	West Pehowa	64	16	33	32	50	...	5	200	45	149	26	25	5	250	450
7.	Khanna Samrala	54	18	29	...	14	80	5	200	54	152	18	21	5	250	450
8.	Ludhiana Jagroan	101	27	108	51	40	17	6	350	17	202	71	27	6	323	673
9. A	Grey Canal	108	27	48	67	94	...	6	350	17	134	152	14	6	323	673
9. B	Muktsar Hithar	87	10	148	...	24	...	6	275	62	217	35	25	6	345	620
10.	Bist Doab	63	36	54	..	42	...	5	200	36	153	38	18	5	250	450

tributory head will give delta in acre inches required for that crop. Summing up deltas of all the crops total delta in acre inches needed for 1000 acres of C. C. A. for the given Kharif Rabi ratio and intensity of irrigation is obtained.

Dividing this total delta in acre inches by 12, we get total water requirements in acre feet for 1000 acres C.C.A. which can be converted into cusec days by further division with 2 because one cusec-day approximately equals two acre feet. The quotient so obtained is the annual water allowance in cusecs for 1000 acres of C. C. A. at the channel head.

The crop patterns thus framed for 1000 acres of C. C. A. can be extended to a portion or whole of the tract.

(ii) *Monthly Water Allowance per 1000 acres of C. C. A.* :—From the above calculations annual water allows is directly arrived at, but this can also be worked out by totalling the monthly water allowances for one year.

For working out monthly requirements in acre feet the area under each crop in 1000 acres of C. C. A. should be multiplied by the monthly requirements in inches for that crop and the product divided by 12 to get acre feet. The sum total of all the figures arrived at after such multiplications and divisions for all the proposed crops during that month will be the total monthly water requirements in acre feet for 1000 acres of C.C.A.

To find out mean discharge at canal head for that month the total water requirements in acre feet is divided by the product of 2 and the number of days in that month, the figure 2 representing the conversion of acre feet into cusec days. The discharge so calculated represents the monthly allowance for that particular month for which it has been worked out.

(*iii*) *Mean Daily Water Allowance for 1000 acres of C.C.A.* To get the mean daily water allowance in cusecs at canal head the annual water requirements in acre feet of 1000 acres of culturable commanded area should be divided by the product of 2x number of full supply days for which a channel is required to run, when one cusec day is approximately equal to 2 acre feet.

Theoretically crop patterns for a particular area should be evolved first and then the capacity of the channel proposed to serve that area should be designed on the basis of mean daily allowance required in cusecs per 1000 acres of C. C. A. at channe head so that full use of the water is made and maximum benefi derived from it.

In practice, channels are run in such a way that in a giver period they get the same number of full supply days at head so a: to ensure that all irrigators in the same tract are treated alike The problem, therefore, is to devise crop patterns from the quantity of water which would thus be available. From previous experience the number of days for which channels run during a normal year, Rabi and Kharif, are known. Crop patterns have been framed based on these expected supplies i.e. capacity factors and fixed water allowance for each zone mentioned in the foregoing pages.

(iv) *Illustration.*—Below is given a concrete example of how to evolve crop pattern to fit in the existing limits for a given tract, say South West of Hissar tract.

Because the tract is included in a zone which is to receive perennial irrigation therefore (i) water allowance =2.75 cusecs per 1000 acre C.C.A. at Distributary head

	(ii)	Full supply days as worked out from capacity factors	278 days
	(iii)	Intensity of irrigation	62%
and	(v)	Absorption losses in water course plus distributary	28%
		Supposed Kharif Rabi ratio	4 : 5
and		size of holding	12·5 acres

Therefore area cropped in 12·5 acres holding

$$= \frac{12{\cdot}5 \times 62}{100} = 7{\cdot}75 \text{ acres.}$$

Because Kharif Rabi ratio is 4:5 therefore out of 7.75 acres the area cropped during Kharif will be 3.44 acres and during Rabi will be 4·31 acres. Hence area cropped in 1000 acres of C. C. A.

$$= \frac{1000 \times 62}{100} = 620 \text{ acres.}$$

Out of 620 acres 275 acres in Kharif and 345 acres in Rabi. If crops are proposed as in column 3 below then the area under each crop, out of 620 acres of cropped area in 1000 acres of C.C.A. will work out as given in column 4 below.

S. No.	*Name of crop*	*%age of crop.*	*Area in acres under each crop in 620 acres of cropped area in 1000 acres C.C.A.*
1.	Kharif Fodder	14·0	87
2.	Sugar cane	2.4	15
3.	Cotton	22·0	136
4.	Other foodgrains Kharif	5·0	31
5.	Orchards and vegetables	1·0	6
	Total Kharif	44·4	275
6.	Rabi fodder	10·0	62
7.	Oilseeds	4·0	25
8.	Wheat	35·0	217
9.	Other foodgrains Rabi	5·6	35
10.	Orchards & vegetables	1·0	6
	Total Rabi	55·6	345
	Total Kharif & Rabi	100	620

For maturing these crops the finally adopted figures of water requirements in the field for the given tract are shown in Table III. By adding 28% to those figures, water requirements of each of the above crops at the distributary head will come to :—

Serial No.	*Name of crop*	*Water requirements at Disty. head (inches).*
1.	Kharif fodder	17·92
2.	Sugar cane	83·20
3.	Cotton	44·80
4.	Other foodgrains (Kharif)	16·64
5.	Orchards and vegetables	51·20
6.	Rabi fodders	51·20
7.	Oilseeds	14·72
8.	Wheat	18·43
9.	Other foodgrains (Rabi)	10·88
10.	Orchards & vegetables	51·20

Adding up the products of total water requirements given above and respective areas under each crop in 620 acres of cropped area we get 17,952 acre inches or 1496 acre feet as the annual water allowance for 1000 acres of C.C.A. of the given tract.

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Therefore mean daily water allowance

$$= \frac{\text{Annual water allowance}}{\text{2x full supply days in the year.}} = \frac{1496}{2\text{x}278} = 2{\cdot}70 \text{ cusecs.}$$

when 2 is the conversion factor of acre-feet into cusec days. Hence the actual water allowance for the crop pattern suggested fits in with the prescribed water allowance of 2·75 cusecs per 1000 acres of C.C. A. Had the calculated water allowance not fitted some adjustments would have been made to bring it in line with the prescribed water allowance.

7. Crop Patterns :—

After taking into consideration the climatic conditions, rainfall, water table, type of soil, local agricultural practices, dust and wind storms, high temperature during summer and other factors as enumerated in the foregoing paragraphs concerning individual tracts of Bhakra Project area, crop patterns have been worked out for each tract. These patterns will serve as models to be imitated by the cultivators of different tracts to enable them to carry on renumerative agriculture by using precious water economically. A brief account of each of the patterns evolved is given below :—

(i) *Rori Chautala Tract* :—The soil of this tract varies from clay loam to sandy loam and 11% of the area is sandy. This tract will receive perennial irrigation. From climatic and soil point of view the land is more suitable for cotton. Areas proposed under cotton, wheat and sugarcane are 24, 35 and 1·5 percent respectively which represents a normal pattern of cropping for this type of soil on the available water supply. No rice has been provided.

In the crop pattern maize has been included in Kharif fodders. This requires approximately 16 inches of irrigation whereas other fodders require about 13 inches. Relative areas 25% of maize and 75% other kharif fodders have been fixed to fit in with the average irrigation of 14 inches.

Out of 62 acres under Rabi fodders in 1000 acres of C. C. A. 42 acres are proposed to be put under Barseem and 20 acres under other fodders. The details of the adopted crop pattern are given in Table VII.

(ii) *Rangoi Tohana Tract* :—The crop pattern for this tract during Kharif shall be different from the Rori Chautala tract on account of different nature of soil. Rice will be suitable crop. Hence

TABLE NO. VIII.

Crop pattern for Rori Chautala Tract

Type of irrigation Perennial; Water allowance: 2·75 cusecs %0 acres at the distributary head.
Intensity 62%
Kharif Rabi ratio 1 : 1·25%

Area cropped in a 12·5 acres holding $= \frac{12\cdot5 \times 62}{100} = 7\cdot75$ acres (Kharif 3·44 acres, Rabi 4·31 acres)

Absorption losses in the water courses and distributary = 28%
Area cropped in 1000 acres C.C.A. = 620 acres (Kharif 275 acres, Rabi 345 acres)

S. No.	Name of crop	%age of cropped area	Area in acres under different crops out of 7·75 acres of cropped area of 12·5 acres holding.	Area in acres under different crops out of 620 acres of cropped area of 1000 acres C. C. A.	Water requirements in inches		Total water requirements in acre inches of 1000 acres C.C.A. (Col. 5×7)	Total water requirements in acre feet of 1000 acres C. C. A. (Col. 8 ÷ 12)	Full supply days in the year as worked out capacity factors in para 5 (i) (c)	Daily water requirement in cs Col. 9/Col. 10 C.C.A.
					In the field.	At the head of Disty: Col. 6 +28% losses				
1	2	3	4	5	6	7	8	9	10	11
1.	Kharif fodder	14·0	1·08	87	14·0C	17·92	1559	129·91		
2.	Sugar cane	1·5	0·12	10	65·0	83·20	832	69·33		
3.	Cotton	24·0	1·86	148	35·0	44·80	6630	552.50		
4.	Rice	...			60·0	76·80				
5.	Other foodgrains (Kharif)	3·9	0·30	54	13·0D	16·64	3900	33·25		
6.	Orchards and vegetables	1·0	0·08	6	40·0	51·20	307	25·58		
	(Total Kharif)	44·4	3·44	275			9727	810·57		
7.	Rabi fodder	10·0	0·78	62B	40·0	51·20	3174	264·50		
8.	Oil seeds	4·0	0·31	25	11·5	14·72	368	30·67		
9.	Wheat	35·0	2·71	217	14·4	18·43	3999	333·25		
10.	Other foodgrains (Rabi)	5·6	0·43	35	8·5	10·88	381	31·75		
11.	Orchards & vegetables	1·0	0·08	6	40·0	51·20	307	25·58		
	Total Rabi	55·6	4·31	345			8229	685·75		
	Total Kharif & Rabi	100	7·75	620			17956	1496·32	278·2	2·7

2A—Represents the conversion of acre feet into cusecs days i.e. 1 cusecs day = 2 acre feet. B—Of 62 acres Rabi fodders, 42 acres is Berseem & 20 acres other fodders. C—Taking 25% maize at 16 inches and 75% others at 13 inches. D—Taking 50% maize at 16 inches and 50% others at 10 inches.

rice has been introduced in the crop pattern as a principal crop during Kharif. It is also expected that due to the nature of soil the area under kharif foodgrains i.e. Maize and Bajra will slightly go up. The introduction of rice and increase in area under Kharif foodgrains has caused the reduction of area under cotton. It has been brought down from 24% in Rori Chautala tract to 14% and the area under grains has been increased from 3.9% to 8% allocating 5% to rice. There shall be no material change in the percentage cropped area of other crops, the details of the crop pattern for this tract are available in table IX.

(iii) *South of Sirsa and Fatehabad Tract*:—This tract is different from the Rangoi Tohana tract but is more similar to the Rori Chautala tract. From climatic and soil point of view it is also very suitable for cotton. The details of the crop pattern for this tract are the same as for Rori Chautala tract and are given in table VIII.

(iv) *Barwala Extension Tract*:—Soils of this tract are light loam on the surface but lower down they are loamy and appear to be more compact. 38,400 acres i. e. nearly 20% area is sandy, out of which 1,000 are covered with sand Tibbas. The area proposed under sugarcane is the same as provided for Rangoi Tohana Tract. Cotton has been prescribed in 22% of cropped area and rice has been altogether omitted. Proportion for Rabi crop is the same as for other tracts of the Hissar district. The detailed crop pattern is in Table X.

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(v) *South West of Hissar Tract*:—The soil of this tract is similar to that of the Barwala Extension tract. Crop pattern will be similar to that of Barwala Extension Tract and are laid down in Table X.

(vi) *West of Pehowa Tract*:—This tract is to receive restricted perennial irrigation. The water allowance is 2·25 cusecs per 1,000 acres of C.C.A. at the distributary head and the intensity of cropping is 45% with Kharif Rabi ratio 4 : 5. The soil of the tract is heavier than the Hissar district. Water-logging also exists at places. The annual rainfall is about 25 inches out of which 18 inches are normally received during monsoon which submerges a portion of this tract under water.

The crop pattern for this area will, therefore, materially differ from tracts of Hissar district particularly with reference to Kharif crops. The areas under sugarcane and rice have, therefore, been

TABLE NO.IX

Crop pattern for Rangoi Tohana Tract.

Type of irrigation ... perennial; Water allowance: 2·75 cs.% 0 acres at the distributary head.
Intensity 62%
Kharif Rabi ratio 1 : 1·25

Area cropped in 12·5 acres holding $\frac{12\cdot5\times62}{100}$ —7·75 acres (Kharif 3·44 acres, Rabi 4 31 acres)

Area cropped in 1000 acres C.C.A. $\frac{1000\times62}{100}$ =620 acres (Kharif 275 acres, Rabi 345 acres)

Absorption in the water courses and distributaries = 28%

S. No.	Name of crop	%age of cropped area	Area in acres under different crops out of 5·63 acres of cropped area of 12·5 acres holding.	Area in acres under different crops out of 673 acres of cropped area of 1000 acres C. C. A.	Water requirements in inches		Total water requirements in inches of 1000 acres C.C.A. (Col. 5×7)	Total water requirements in acre feet of 1000 C. C. A. (Col. 8÷12)	Full supply days in the year as worked out from capacity factors in para 5 (i) (c)	Daily water requirement in cs. Col. 9/(Col. 10 x2A).
					In the field.	At the head of Disty: (Col. 6 +28% losses)				
1	2	3	4	5	6	7	8	9	10	11
1.	Kharif fodder ...	14 0	1·08	87	14·0	17 92	1559	129 92		
2.	Sugar cane ...	2·4	0·19	15	65·0	83·20	1248	104·00		
3	Cotton ...	14·0	1·08	87	35·0	44·80	3897	324.75		
4.	Rice	5 0	0·39	31	60·0	76 80	2381	193·40		
5.	Other Foodgrains ...	8 0	0·62	50	D 13 0	16·64	832	69·33		
6.	Orchards and vegetables ...	1·0	0·08	6	40.0	51· 0	307	25·58		
	Total Kharif ...	44·4	3·44	275			10461	851·98		
7.	Rabi Fodder ...	10 0	0·78	62B	40·0	51·20	3174	264·50		
8.	Oil seeds ...	4·0	0·31	25	11 5	14·72	368	30·67		
9.	Wheat ...	35·0	2·71	217	14·4	18·43	3999	333·25		
10.	Other Foodgrains ...	5·6	0·43	35	8·5	10·88	381	31·75		
11.	Orchards & vegetables ...	1·0	0·08	6	40·0	51·20	307	25·58		
	Total Rabi ...	55·6	4·31	345			8229	535·75		
	Total Kharif & Rabi ..	100	7·75	620			19231	1537·73	218·2	2·7

2A—Represents the conversion of acre feet into cusec day i.e. 1 cusec day=2 acre feet.
B—of 62 acres Rabi fodders, 42 acres is Berseem & and 20 acres other fodder.
C—Taking 25% maize at 16 inches and 75% others at 13 inches.
D—Taking 50% maize at 16 inches and 50% others at 10 inches.

TABLE NO. X.

Crop pattern for Barwala Tract

Type of irrigation........Perennial; Water allowance: 2·75 cusecs %0 acres at the distributary head.
Intensity 62%
Kharif Rabi ratio 1 : 1·25
Area cropped in a 12·5 acres holding $\frac{12 \cdot 5 \times 62}{100}$ =7·75 acres (Kharif 3·44 acres, Rabi 4·31 acres.)

Area cropped in 1000 acres C.C.A.= $\frac{1000 \times 62}{100}$ =620 acres (Kharif 275 acres, Rabi 345 acres)

Absorption losses in the water courses and distributary=28%

S. No.	Name of crop	%age of cropped area	Area in acres under different crops out of 7·75 acres of cropped area of 12·5 acres holding.	Area in acres under different crops out of 620 acres of cropped area of 1000 acres C. C. A.	Water requirements in inches		Total water requirements in acre inches of 1000 acres C.C.A. (Col. 5×7)	Total water requirements in acre feet of 1000 acres C. C. A. (Col. 8÷12)	Full supply days in the year as worked out from capacity factors in para 8·5 (i) (c)	Daily water requirement in cs. Col. 9/Col. 10 x2A.
					In the field.	At the head of Disty: (Col. 6 +28% losses)				
1	2	3	4	5	6	7	8	9	10	11
1.	Kharif fodder	14·0	1·08	87	14·0C	17·92	1559	129·92		
2.	Sugar cane	2·4	0·19	15	65·0	83·20	1248	104·00		
3.	Cotton	22·0	1·70	136	35·0	44·80	6093	507.75		
4.	Other foodgrains (Kharif)	5·0	0·39	31	13·0D	16·64	516	43·00		
5.	Orchards and vegetables	1·0	0·08	6	40·0	51·20	307	25·58		
	(Total Kharif)	44·4	3·44	275			9723	810·25		
6.	Rabi fodder	10·0	0·78	62B	40·0	51·20	3174	264·50		
7.	Oil seeds	4·0	0·31	25	11·5	14·72	368	30·67		
8.	Wheat	35·0	2·71	217	14·4	18·43	3999	333·25		
9.	Other foodgrains (Rabi)	5·6	0·43	35	8·5	10·88	381	31·75		
10.	Orchards & vegetables	1·0	0·08	6	40·0	51·20	307	25·58		
	Total Rabi	55·6	4·31	345			8229	685·75		
	Total Kharif & Rabi	100	7·75	620			17952	1496	278·2	2·7

2A—Represents the conversion of acre feet into cusec day (1 cusec day=2 acre feet).

TABLE NO. XI.

Crop pattern for West of Pehowa Tract.

Type of irrigation ... Restricted Perennial; Water allowance: 2·25% 0 acres at the distributary head
Intensity 45%
Kharif Rabi ratio 1 : 1·25
Area cropped in a 12·5 acres holding $\frac{12\cdot5\times45}{100}$=5·625 acres (Kharif 2·5 acres, Rabi 3·125 acres.)

Area cropped in 1000 acres C.C.A.=$\frac{1000\times45}{100}$=450 acres (Kharif 200 acres, Rabi 250 acres)

Absorption losses in the water courses and distributary=28%

S. No.	Name of crop	%age of cropped area	Area in acres under different crops out of 5·63 acres of cropped area of 12·5 acres holding.	Area in acres under different crops out of 450 acres of cropped area of 1000 acres C. C. A.	Water requirements in inches		Total water requirements in inches of 1000 acres C.C.A. (Col. 5×7)	Total water requirements in acre feet of 1000 C. C. A. (Col. 8÷12)	Full supply days in the year as worked out from capacity factors in para 5 (i) (a)	Daily water requirement in cs Col. 9/(Col. 10 x2A).
					In the field.	At the head of Disty: (Col. 6 +28% losses)				
1	2	3	4	5	6	7	8	9	10	11
1.	Kharif fodder	14·00	0·80	64	12	15·36	893	81·93		
2.	Sugar cane	3·5	0·20	16	50	64·00	1024	85·33		
3.	Cotton	7·5	0·42	33	22	28·16	925	77.10		
4	Rice	7 0	0·40	32	50	64·00	2048	170·67		
5.	Other foodgrains (Kharif)	11·4	0·62	50	7	8·96	412	34·33		
6.	Orchards and vegetables	1·0	·06	5	30	38·40	192	16·00		
	(Total Kharif)	44·4	2·50	200			5584	465·33		
7.	Rabi fodder	10·0	0·56	45	40	51·20	2304	192·00		
8.	Oil seeds	6·0	0·32	25	9	11·41	285	23·75		
9.	Wheat	33·0	1·87	149	14	17·92	2670	222·59		
10.	Other foodgrains (Rabi)	5·6	0·32	26	7	8·96	233	19·42		
11.	Orchards & vegetables	1·0	0 06	5	30	38·40	192	16·00		
	Total Rabi	55·6	3·13	250			5684	473·67		
	Total Kharif & Rabi	100	5·63	450			11268	939·00	203·2	2·3

2A—Represents the conversion of acre feet into cusec day (1 cusec day=2 acre feet).

raised to 3·5% and 7·0% respectively as against 2·4% and 5·0% provided in the crop pattern for Rangoi Tohana tract. Due to increase under rice and sugarcane, more rainfall and other factors only 7·5% land is proposed to be put under cotton. The total water requirements of the crops have also been reduced partly due to absence of irrigation during July and August and partly due to proportionately higher rainfall and higher moisture present in the soil on account of high water table. The details of the crop pattern for this tract are available in table XI.

(*vii*) *Khanna Samrala Tract*:—This tract like West of Pehowa tract is also to receive restricted perennial irrigation with allowance of 2·25 cusec per 1,000 acres of C. C. A. and 45% intensity. The rainfall of this tract is about 24 inches. The soil is mostly sandy to loam. The sandy soil locally known as Bhudi is very suitable for groundnut cultivation. Out of 44·4% of area to be cropped during Kharif, 18% has been allocated for groundnuts which is the principal crop of the tract. The area under cotton shall be slightly less than the Pehowa tract but major reduction has to be effected under Kharif goodgrains because major part of land shall be under groundnut. The details of the crop pattern for this tract are available in table XII.

(*viii*) *Sidhwan Branch of Ludhiana Jagraon Tract* :—This tract like the Grey Canal tract is also included in the non-perennial zone and has been allowed the same water allowance intensity of cropping and Kharif Rabi ratio. Due to variation in the nature of soil as compared to the adjoining Grey Canal tract the area under cotton has been increased, areas for rice and other Kharif foodgrains decreased and groundnuts introduced. The most important Kharif crop will be cotton which would be 16% i. e. a little less than 1/3rd of the Kharif area. Rice will be 7·5%, groundnut 2·5% and other foodgrains 6%. On account of such pertinant reasons of soil, climate, rainfall etc., the area under wheat has been raised to 30% as against 20% in the Grey Canal tract. Thus wheat shall be the most important crop during Rabi accounting for approximately 2/3rd of the cropped area during that season. The details of the crop pattern for this tract are available in Table XIII.

TABLE NO. XII.

Crop pattern for Khanna Samrala Tract.

Type of irrigation ... Restricted Perennial; Water allowance: 2·25 cs.% 0 acres at the distributary head.
Intensity 45%
Kharif Rabi ratio 1 : 1·25
Area cropped in a 12·5 acres holding $\frac{12·5 \times 45}{100}$ =5·63 acres (Kharif 2·5 acres, Rabi 3·13 acres.)

Area cropped in 1000 acres C.C.A.= $\frac{1000 \times 45}{100}$ =450 acres (Kharif 200 acres, Rabi 250 acres)

Absorption losses in the water courses and distributary=28%

S. No.	Name of crop	%age of cropped area	Area in acres under different crops out of 5·63 acres of cropped area of 12·5 acres holding.	Area in acres under different crops out of 450 acres of cropped area of 1000 acres C. C. A.	Water requirements in inches		Total water requirements in inches of 1000 acres C.C.A. (Col. 5×7)	Total water requirements in acre feet of 1000 C. C. A. (Col. 8÷12)	Full supply days in the year as worked out from capacity factors in para 5 (i) (a)	Daily water requirement in cs. Col. 9/(Col. 10 x2A).
					In the field.	At the head of Disty: (Col. 6 +28% losses)				
1	2	3	4	5	6	7	8	9	10	11
1.	Kharif fodder	12·0	0·68	54	13	16·64	899	74·88		
2.	Sugar cane	4·0	0·22	18	54	69·12	1244	103·68		
3.	Cotton	6·4	0·36	29	22	28·16	817	68.05		
4	Groundnut	18·0	1·01	80	13	16·64	1331	110·93		
5.	Other Foodgrains	3·0	0·17	14	13	16·64	233	19·41		
6.	Orchards and vegetables	1·0	0·06	5	40	51·20	256	21·33		
	Total Kharif	44·4	2·50	200			4780	398·28		
7.	Rabi Fodder	12·0	0·68	54	40	51·20	2765	230·40		
8.	Oil seeds	4·6	0·26	21	10	12·80	269	22·40		
9.	Wheat	34·0	1·91	152	13	16·64	2529	210·77		
10.	Other Foodgrains	4·0	0·22	18	8·5	10·88	196	16·32		
11.	Orchards & vegetables	1·0	0·06	5	40	51·20	256	21·33		
	Total Rabi	55·6	3·13	250			6015	501·22		
	Total Kharif & Rabi	100	5·63	450			10795	899·50	203·2	2·21

2A—Represents the conversion of acre feet into cusec day i.e. 1 cusec day=2 acre feet.

TABLE NO. XIII.

Crop pattern for Ludhiana Jagraon Tract (Sidhwan Branch Tract)

Type of irrigation...... Non perennial; Water allowance: 3·5 cs.% 0 acres at the distributary head.
Intensity 35% during Kharif only.
Kharif Rabi ratio 52 : 48
Area cropped in a 12·5 acres holding during Kharif=4·38 acres.
Area cropped in 12·5 acres holding during Rabi=4·04"
Area cropped in 1000 acres C.C.A.=673 acres (Kharif 350 acres, Rabi 323 acres)

Absorption losses in the water courses and distributary=28%

S. No.	Name of crop	%age of cropped area	Area in acres under different crops out of 5·63 acres of cropped area of 12·5 acres holding.	Area in acres under different crops out of 673 acres of cropped area of 1000 acres C. C. A.	Water requirements in inches		Total water requirements in inches of 1000 acres C.C.A. (Col. 5×7)	Total water requirements in acre feet of 1000 C. C. A. (Col. 8÷12)	Full supply days in the year as worked out from capacity factors in para 5 (i) (b)	Daily water requirement in cs. Col. 9/(Col. 10 x2A).
					In the field.	At the head of Disty: (Col. 6 +28% losses)				
1	2	3	4	5	6	7	8	9	10	11
1.	Kharif fodder ...	15·0	1·26	101	13	16·64	1681	140 08		
2.	Sugar cane ...	4·0	0·34	27	40	51·20	1382	115·17		
3.	Cotton ...	16·0	1·36	100	25	32·00	3456	288.00		
4.	Rice ...	7·5	0·63	51	60	76·80	3917	326·42		
5.	Groundnut ...	2·5	0·21	17	13	16·64	283	23·58		
6.	Other Foodgrains ...	6·0	0 50	40	13	16·64	666	55·50		
7.	Orchards and vegetables ...	1·0	·08	6	40	51·20	307	25·50		
	Total Kharif ...	52·0	4·38	350			11692	974·33		
8.	Rabi Fodder ...	2·5	0·21	17	4	5·12	87	7·25		
9.	Oil seeds ...	4·0	0·34	27	4	5·12	138	11·50		
10.	Wheat ...	30·0	2·53	202	4	5·12	1034	86·17		
11.	Other Foodgrains ...	10·5	0·88	71	4	5·12	364	30·33		
12	Orchards & vegetables ...	1·0	·08	6	4	5·12	31	2·58		
	Total Rabi ...	48·0	4·04	323			1654	137·83		
	Total Kharif & Rabi ..	100 0	8·42	673			13344	1112·16	157·8	3·52

2A—Represents the conversion of acre feet into cusec day i.e. 1 cusec day=2 acre feet.

(ix a) *Grey Canal Tract Excluding Muktsar Hithar Area :*—It is included in the zone to receive non-perennial irrigation i.e. for 6 months from May to October. Water in October has been provided for Rabi sowings and maturing late Kharif crops. The mean daily water allowance prescribed for this zone is 3·5 cusecs per 1000 acres of C.C.A. at the distributary head and intensity of cropped area over C.C.A. is 35% during Kharif only. As the water is allowed during October for Rabi sowings, the Kharif Rabi ratio like the existing non-perennial Grey Canals shall be 52:48. The area is waterlogged. In the crop pattern only 4 inches water has been provided for sowing each of the Rabi crops. Rice has been included during Kharif and the area put under it is 10% while cotton has been reduced to 7% as against 12% provided in the crop pattern for Bist Doab tract. Kharif foodgrains other than rice constitute 14%. Supply being non-perennial percentage of area under wheat has been brought down to 20. The details of the crop pattern for this tract are available in table XIV.

(ix b) *Muktsar Hithar Sub-tract :*—An area of about 69,000 acres lying in Ferozepur District which will receive perennial irrigation is known as Muktsar Hithar area. The crop pattern for Sori Chautala tract will be quite suitable for this area also and table VIII should be consulted for the same

(x) *Bist Doab Tract :*—This tract is provided with restricted perennial irrigation. The soil of this tract is generally silty to loam and is most suitable for the growing of sugarcane and cotton. Maize, Chari and Bajra are other important crops during Kharif and Wheat, Gram and Massur during Rabi. In the crop pattern area under cotton and sugarcane has been increased by 12% and 8% respectively. Areas under other crops have correspondingly been reduced without neglecting the primary needs of the Zamindars with regard to them. Rice would not do well in this area and has therefore, been omitted in the crop patttern. The details of the crop pattern are given in Table XV.

8. (i) **Expected increase in yield of crops**. An attempt has been made to estimate the area that will be put under various Kharif and Rabi crops according to the prescribed water allowances in each of the three irrigation zones, expected produce of each crop and the value of the produce for the Punjab, Pepsu and

TABLE NO. XIV.

Crop pattern for Grey Canal Tract

Type of irrigation . ... Non perennial; Water allowance: 3·5 cs.% 0 acres at the distributary head.
Intensity 35% during Kharif only.
Kharif Rabi ratio 52 : 48
Area cropped in 12·5 acres C.C.A. holding in the ratio of 52 Kharif 48 Rabi=8.42 (4.33 acres, 4·04 acres)
Area cropped in 1000 acres C.C.A.=673 acres (Kharif 350 acres, Rabi 323 acres)

Absorption losses in the water courses and distributary=28%

S. No.	Name of crop	%age of cropped area	Area in acres under different crops out of 5·63 acres of cropped area of 12·5 acres holding.	Area in acres under different crops out of 673 acres of cropped area of 1000 acres C. C. A.	Water requirements in inches		Total water requirements in inches of 1000 acres C.C.A. (Col. 5×7)	Total water requirements in acre feet of 1000 C. C. A. (Col. 8÷12)	Full supply days in the year as worked out from capacity factors in para 5 (i) (b)	Daily water requirement in cs. Col. 9/(Col. 10 x2A).
					In the field.	At the head of Disty: (Col. 6 +28% losses)				
1	2	3	4	5	6	7	8	9	10	11
1.	Kharif fodder ...	16	1·35	108	13	16·64	1797	149·75		
2.	Sugar cane ...	4	0·34	27	40	51·20	1382	115·17		
3	Rice ...	10	0·84	67	60	76·80	5146	428.83		
4.	Other Foodgrains ...	14	1·18	94	13	16·64	1564	130·33		
5.	Cotton ...	7	·59	48	25	32·00	1536	128.00		
6.	Orchards and vegetables ...	1	1·08	6	40	51·20	307	25·50		
	Total Kharif ...	52	4·38	350			11732	977·66		
7.	Rabi Fodder ...	2·5	0·21	17	4	5·12	87	7·25		
8.	Oil seeds ...	2·0	0·17	14	4	5·12	72	6·00		
9.	Wheat ...	20·0	1·68	134	4	5·12	686	57·17		
10.	Other Foodgrains ...	22·5	1·90	152	4	5·12	778	64·83		
11.	Orchards & vegetables ...	1·0	0·08	6	4	5·12	31	2·58		
	Total Rabi ...	48·0	4·04	323			1654	137·83		
	Total Kharif & Rabi ..	100	8·42	673			13386	1115·5	157·8	3·53

2A—Represents the conversion of acre feet into cusec day i.e. 1 cusec day=2 acre feet.

TABLE NO. XV.

Crop pattern for Bist Doab Tract (Jullundur)

Type of irrigation … ..Restricted perennial; Water allowance: 2·25 cs.% 0 acres at the distributary head.
Intensity 45%
Kharif Rabi ratio 1 : 1·25

Area cropped in 12·5 acres holding $\frac{12{\cdot}5\times45}{100}$ 5·63 acres (Kharif 2·5 acres, Rabi 3·13 acres)

Area cropped in 1000 acres C.C.A.=450 acres (Kharif 200 acres, Rabi 250 acres)
Absorption losses in the water courses and distributary=28%

S. No.	Name of crop	%age of cropped area	Area in acres under different crops out of 5·63 acres of cropped area of 12·5 acres holding.	Area in acres under different crops out of 673 acres of cropped area of 1000 acres C. C. A.	Water requirements in inches		Total water requirements in inches of 1000 acres C.C.A. (Col. 5×7)	Total water requirements in acre feet of 1000 C. C. A. (Col. 8÷12)	Full supply days in the year as worked out from capacity factors in para 5 (i) (a)	Daily water requirement in cs. Col. 9/(Col. 10 x2A).
					In the field.	At the head of Disty: (Col. 6 +28% losses)				
1	2	3	4	5	6	7	8	9	10	11
1.	Kharif fodder …	14·0	·78	63·0	13	16·64	1048·0	87·33		
2.	Sugar cane …	8·0	·45	36·0	52	66·56	2396 0	199·66		
3.	Cotton …	12·0	·68	54·0	20	25·60	1382·0	115.16		
4.	Other Foodgrains …	9·4	·53	42·0	13	16·64	699·0	58·25		
5.	Orchards and vegetables …	1·0	·06	5·0	40	51·20	256·0	21·33		
	Total Kharif …	44·4	2·50	200			5781·0	481·73		
6.	Rabi Fodder …	8·0	·45	36	40	51·20	1843·0	153·58		
7.	Oil seeds …	34·0	1·91	153	13	16·64	2546·0	215·17		
8.	Wheat …	8·6	·48	38	8·5	10·88	473 0	38·41		
9.	Other Foodgrains …	4·0	0·23	18	10	12·80	230·0	19·16		
10.	Orchards & vegetables …	1·0	0·06	5	40	51·20	256 0	21·33		
	Total Rabi …	55·6	3·13	250			5348·0	445·65		
	Total Kharif & Rabi…	100	5·63	450			11129·0	927·4	203·2	2·23

2A—Represents the conversion of acre feet into cusec day i.e. 1 cusec day=2 acre feet.

Rajasthan States. These are given in Table XVI. These figures have been arrived at on the assumption that the recommended crop patterns will be adopted by the cultivators in the whole project area. The relevant figures are given in a summary at the end of the table XVI.

(ii) (a) *Total value of the additional produce statewise in new areas is given on table XVI and is also abstracted below :*—

		Punjab	Pepsu	Rajasthan	Total
Kharif	Rs.	20,81,31,135	8,01,47,720	5,61,61,400	34,44,40,255
Rabi	Rs.	22,94 59,732	8,59,22,711	6,05,63,600	37,59,46,043
Total	Rs.	43 75 90,867	16,60,70,431	11,67,25,000	72,03,86 298

(b) *Increase in prosperity in the existing areas of Sirhind Canal in Punjab and Pepsu.* In the existing areas of Sirhind Canal in Punjab and Pepsu which have not been included in the table No. XVI, the area under long staple cotton has actually increased by about 209490 acres on account of improved capacity factor and water allowance and thereby change in crop pattern. This produces 120063 bales of extra cotton lint. Therefore, the total extra produce of long staple cotton comes to 587125 bales and its value will be Rs. 54028350, raising the total value of the additional agricultural produce from Rs. 72,03,86,298 to Rs. 774414648, say Rs. 77·5 crores. The total income to the Punjab State will thus be Rs. 48,07,45,867.

(iii) *Total yield of crops as compared with the Project Estimate.* The total yields of the crops as arrived at in Table XVI and those given in the project estimate are compared as below :—

Serial No.	Name of crop	Project Estimate	Crop Planning Estimate.
1.	Sugarcane	5,44,000 tons	14,82,010 tons
2.	Cotton	8,00,000 bales	5,87,125 bales
3.	Foodgrains	11,30,000 tons	8,50,835 tons
4.	Fodder		
	(i) Green	15,00,000 tons	45,27,718 tons
	(ii) Dry		15,00,442 tons
5.	Oilseeds.	1,00,000 tons	36,284 tons

The difference in the estimates of produce in the two cases is due to the difference in the types of Crop Patterns adopted. The project estimate was based on the Crop Patterns actually obtained

TABLE

Showing anticipated yield and Income from the Various Crops to be put in

Names of the Tracts in each zone according to States	Total C C A. area.	Total area to be cropped annually	Kharif Green Foder Area in acres	Kharif Green Foder Yield @ 150 mds. per acre (mds.)
1	2	3	4	5
A. PUNJAB.				
ZONE NO 1 RESTRICTED PERENNIAL.				
1. Pehowa Tract	4,12,704	1 85,717	26,413	39,61,950
2. Khanna Samrala Tract	1,39 500	62,775	7,533	11,29,950
3. Bist Doab Tract	4,50,000	2,02 500	28,350	42,52 500
4. Ruper Nangal and South of Patiala Tracts (Ambala District)	95 931	43,169	6,044	9 06,600
TOTAL	10,98,135	4,94,161	68,340	1,02,51,000
ZONE NO.II NON-PERENNIAL				
1. Grey Canal Tract	3,82,500	1,33,875	21,483	32,22,450
2. Ludhiana Jagraon Tracts (north of Abohar Br. between Kotla and Bhatinda Br. and North of Bhatinda Br.)	1,10,461	38,661	5,802	8,70,300
TOTAL	4,92,961	1,72 536	27 285	40, 2,750
ZONE NO. III PERENNIAL				
1. Rori Chautala Tract	6,15,011	3,81,307	53,506	80,25,900
2. Tohana Rangoi Tract	3,55,717	2,20,544	30,947	46,42,050
3. South of Sirsa and Fatehabad	3,38 312	2,09 753	29,433	44,14,950
4. Barwala Extension Tract	1,32,818	82,347	11,555	17,33 250
5. South West of Hissar Tract	67,323	41,740	5 857	8,78,550
6. Sirsa Br. & Old Ghaggar Canal area (Karnal Hissar District.)	5,79,394	3,59 224	50,407	75,61,050
7. Muktsar Hithar	62,901	38,999	5,472	8 20 800
8. Ferozepore including Sirhind Canal Extension.	1,11,028	68,837	9,659	14,48,850
9 Areas where water allowance is to be improved. (F.Z.P.)	2,29,200	1,42,102	19,940	29,91,000
Total	24,91,704	15,44 853	2,16,776	3,25,16,400
TOTAL A. PUNJAB	40,82,800	22,11 550	3,12,401	4,68,60,150
B. RAJASTHAN	9,20,000	5,70,400	80,040	1,20,06,000
C. PEPSU	10,87,980	8,22,323	1,16,076	1,74,11,400
Grand Total (A+B+C)	60,90,780	36,04,273	5 08,517	7,62,77,550

No. XVI.

The Bhakra Project areas, as a result of Cananl Irrigation, annually.

Crops Area, Yield and Value in Rupees.							
	Sugar Cane			Cotton			
Yield @ Re. /8/- per md. (Rs.)	Area in acres.	Yield @ 40 mds. of Gur per acre (mds.)	Yield @ Rs. 10/-/- per md. of Gur. (Rs.)	Area in acres.	Yield @ 10 mds. of Kapas per acre. (mds)	Value @ Rs. 30/-/- per md. of Kapas (mds.)	Area in acres
6	7	8	9	10	11	12	13
19,80,975	6,603	2,64,120	26,41,209	13 619	1,36,190	40.85,700	13,207
5,64,975	2,510	1,00,400	10,04,000	4,460	40,460	12,13 800	...
21,26,250	16,200	6.48,000	64,80,000	24,300	2,43,000	72,90,000	...
4,53,300	1,453	1,38,120	13,81,200	5 180	51,800	15,54,000	...
51,25,500	22,766	11,50,640	1,15,06,400	47 145	4,71,450	1,41.43,500	13,207
16,11,225	5,372	2,14,880	21,48,800	9,548	95,480	28,64,400	13,328
4,35,150	1 551	62,040	6,20,400	6,204	62,040	18,61,200	2,930
20,46,375	6,923	2,76,920	27,69,200	15,752	1,57,520	47,25,600	16,258
40,12,950	6,150	2,46,000	24 60,000	91,022	9.10,220	2,73.06,600	...
23.21,025	5 336	2 13 440	21,34,400	30,947	3,09,470	92,84,100	10,671
22,07,475	3,383	1,35 320	13,53,200	50,070	5,00,700	1,50,21,000	...
8,66 625	1,990	79,600	7 96,000	18.067	1,80,670	54,20,100	...
4,39,275	1,010	40,400	4.04 000	9,157	91,570	27,47,100	...
37,80,525	8,691	3.47,640	34 76,400	78,797	7,87,970	2,36,39,100	...
4 10,400	629	25,160	2,51,600	9,309	93,090	27,92,700	...
7,24,425	1,110	44.400	4,44,000	16,431	1,64,310	49,29,300	...
14,95,500	2,292	91,680	9,16,800	33,921	3,39,210	1,01,76,300	...
1,62,58,200	30,591	12,23,640	1,22,36,400	3,37,721	33,77,210	10,13,16.300	10,671
2,34,30,075	66,280	26,51,200	2,65,12,000	4,00,180	40,06,180	12,01,85,400	40,136
60,03,000	9,200	3,68,000	36,80,000	1,36,160	13,61,600	4.08,48,000	...
87,05,700	28,261	11,30,440	1,13,04,400	1,63.815	16,38,150	4,91,44,500	3,736
3,81,38,775	1,03,741	41,49 640	4,14,96,400	7,00,593	70,05,930	21,01,77,900	43,872

TABLE

Showing anticipated yield and Income from the Various Crops to be put in

Name of the Tracts in each zone according to States.	Kharif crops, area, yield				
	Rice		Groundnuts		
	Yield @ 20 mds, per acre (mds.)	Value @ Rs.9/-/- per md.	Area in acres.	Yield @ 12 mds. per acre (mds.)	Value @ Rs. 10/-/- per md. (Rs.)
1	14	15	16	17	18
A. PUNJAB.					
ZONE NO 1 RESTRICTED PERENNIAL					
1. Pehowa Tract	2,64,140	23,77,260	...	...	...
2. Khanna Samrala Tract	...	...	11,160	1,33,920	13,39,200
3. Bist Doab Tract	...	...	...	...	...
4. Ruper Nangal and South of Patiala Tracts (Ambala District)	...	—	...	...	...
TOTAL	2,64,140	23,77,260	11,160	1,33,920	13,39,200
ZONE NO.II NON-PERENNIAL					
1. Grey Canal Tract	2,66,560	23,99,040	...	...	...
2. Ludhiana Jagraon Tracts (north of Abohar Br. between Kotla and Bhatinda Br. and North of Bhatinda Br.)	58,600	5,27,400	976	11,712	1,17,120
TOTAL	3,25,160	29,26,440	976	11,712	1,17,120
ZONE NO. III PERENNIAL					
1. Rori Chautala Tract	...	...	...	...	—
2. Tohana Rangoi Tract	2,13,420	19,20,780	...	...	...
3. South of Sirsa and Fatehabad	...	...	...	...	...
4. Barwala Extension Tract	...	...	...	...	...
5. South West of Hissar Tract	...	...	...	...	...
6. Sirsa Br. & Old Ghaggar Canal area (Karnal Hissar District.)	...	...	...	...	...
7. Muktsar Hithar	—	...	...	...	...
8. Ferozepore including Sirhind Canal Extension.	...	...	...	...	...
9. Areas where water allowance is to be improved. (F.Z.P.)	...	...	...	...	...
Total	2,13,420	19,20,780	...	...	...
TOTAL A. PUNJAB.	8,02,729	72,24,480	12,136	1,45,632	14,56,320
B. RAJASTHAN	...	...	...	...	...
C. PEPSU.	74,720	6,72,480	...	...	...
GrandTotal (A+B+C)	8,77,440	78,96,960	12,136	1,45,632	14,56,320

No. XVI—*contd.*

The Bhakhra Project areas, as a result of Canal Irrigation, annuully.

and value in rupees

Other food grains			Dry fodder		Vegetables and orchards		
Area in acreas	Yield @ 10 mds. per acre (mds.)	Value @ Rs. 8/-/- per md. (Rs.)	Day fodder yield 25 mds. per acre	Value @ Rs. 2/-/- per md.	Area in acres.	Value @ Rs. 500/ /- per acre (Rs.)	Total Area
19	20	21	22	23	24	25	26
20,635	2,06,350	16,50,800	5,15,875	10,31,750	2,064	10,32,000	82,541
1,953	19,530	1,56,240	48,825	97,650	698	3,49,000	27,900
18,900	1,89,000	15,12,000	4,72,500	9,45,000	2,250	11,25,000	90,000
4,029	40,290	3,22 320	1,00,725	2,01,450	480	2,40,000	19,186
45,517	4 55,170	36,41,360	11,37,925	22.75,850	5,492	27,40,000	2,19,627
18,698	1,86,980	14,95 840	4,67,450	9,34,900	1,193	5,96,500	69,622
2,298	22,980	1,83,840	57,450	1,14,900	345	1.72,500	20,106
20,996	2,09 960	16,79,680	5,24,900	10,49,800	1,538	7,69,000	89,728
14,760	1,47,600	11,80,800	3,69,000	7,38,000	3,690	18,45,000	1,69,128
17,786	1,77,860	14,22,880	4,44,650	8,89,300	2,135	10,67,500	97,822
8,120	81,200	6,49,600	2,03,000	4,06,000	2,030	10,15,000	93,036
4,117	41,170	3,29,360	1,02,925	2,05 850	796	3,98,000	36,525
2,087	20,870	1,66.960	52.175	1,04,350	404	2,02,000	18,515
17,962	1,79,620	14,36,960	4,49,050	8,98,100	3,476	17,38,000	1,59,333
1,510	15,100	1,20,800	37,750	75,500	378	1,89,000	17,298
2,666	26,660	2 13,280	66,650	1.33 300	666	3,33,000	30,532
5,501	55,010	4,40,080	1,37,525	2,75,050	1,375	6,87,500	63,029
74,509	7,45,090	59,60,720	18,62,725	37,25,450	14,950	74,75,000	6,85,218
1,41,022	14,10,220	1,12,81,760	35,25,550	70,51,100	21,980	1,09,90,000	9,94,573
22,080	2,20,800	17,66,400	5,52,000	11,04,000	5,520	27,60,000	2,53,000
47,678	4,76,780	38,14,240	11,91,950	23,83,900	8 245	41,22,500	3,67,811
2,10,780	21,07,800	1,68,62,400	52,69,500	1,05,39,000	35,745	1,78,72,500	16,15,384

TABLE

Showing anticipatad yield and Income from the Various Crops to be put in

Name of the Tracts in each zone according to States	RABI CROPS AREA, YIELD AND				
	Green Fodders				
	Area in acres	Yield @ 150 mds. per acre (mds.)	Value @ Rs. -/8/- per md. (Rs.)	Area in Acres.	Yield @ 15 mds per acre (Rs.)
1	27	28	29	30	31
A. PUNJAB.					
ZONE NO. 1 RESTRICTED PERENNIAL.					
1. Pehowa Tract	18,572	27,85,800	13,92,900	61,493	9,22,395
2. Khanna Samrala Tract	7,533	11,29,950	5,64,970	21,204	3,18,060
3. Bist Doab Tract	16,200	24,30,000	12,15,000	61,850	10,32,750
4. Ruper Nangal and South of Patiala Tracts (Ambala District)	3,454	5,18,100	2,59,050	14,677	2,20,155
TOTAL	45,759	68,63,850	34,31,925	1,66,224	24,93,360
ONE NO.II NON-PERENNIAL					
1. Grey Canal Tract	3,382	5,07,300	2,53,650	26,656	3,99,840
2. Ludhiana Jagraon Tracts (north of Abohar Br. between Kotla and Bhatinda Br. and North of Bhatinda B .)	977	1,46,550	73,275	11,604	1,74,060
TOTAL	4,359	6,53,850	3,26,925	38,260	5,73,900
ZONE NO. III PERENNIAL					
1. Rori Chautala Tract	38,131	27,19,650	28,59,825	1,33,457	20,01,855
2. Tobana Rangoi Tract	22,054	33,08,100	16,54,050	77,190	11,57,850
3. South of Sirsa and Fatehabad	20,975	31,46,250	15,73,125	73,413	11,01,195
4. Barwala Extension Tract	8,235	12,35,250	6,17,625	28,821	4,32,315
5. South West of Hissar Tract	4,174	6,26,100	3 13 050	14,608	2,19,120
6. Sirsa Br. & Old Ghaggar Canal area (Karnal Hissar District.)	35,923	53,88,450	26,94,225	1,25,729	18,85,935
7. Muktsar Hitnar	3,900	5,85,000	2,92,500	13,650	2,04,750
8. Ferozepore including Sirhind Canal Extension.	6,884	10,32,600	5,16,300	24,093	3,61,395
9. Areas where water allowance is to be improved. (F.Z.P.)	14,210	21,31,500	10.65,750	49,736	7,46,040
Total	1,54,486	2,31,72,900	1,15,86,450	5,40,697	81,10,455
TOTAL A. PUNJAB	2,04,604	3,06,90,600	1,53,45,300	7,45,181	1,11,77,715
B. RAJASTHAN	57,040	85,56,000	42,78,000	1,99,640	29,94,600
C. PEPSU	75,013	1,12,51,950	56,25,975	2,79,942	41,99,130
Grand Total (A+B+C)	3,36,657	5,04,98,550	2,52,49,275	12,24,763	1,83,71,445

No. XVI.—(*contd.*)

The Bhakra Project area, as a result of Canal Irrigation, annually.

VALUE IN RUPEES.

Wheat			Other Food Grains			Oil Seed	
Value @ Rs. 12/-/- per md. (Rs.) 32	Bhusa @ 30 mds. pe. acre 33	Value @ Rs. 2/ /- pe md. 34	Area in acres. 35	Yield @ 10 mds. per acre (mds.) 36	Value @ Rs. 8/-/- per md. (Rs.) 37	Area in acres. 38	Yield @ 6 mds. per acre (Mds.) 39
1,10,68,740	18,44.790	36,89,580	10,730	1,07,300	8,58,400	10,318	61,508
38 16,720	6,36,120	12,72.240	2,511	25,110	2,00,800	2,930	17,580
1,23,93,000	20,65,500	41,31,000	17 100	1,71,000	13,68,000	8,100	48.600
26,41,860	4.40,310	8.80.620	3,615	36,450	2,91,600	1,727	10 362
2,99 20,320	49 86 720	99,73,440	33.986	3.39,860	27,18,880	23,075	1,38,450
47.98,080	7 99,680	15,99,360	30.237	3.02,370	24,18,960	2,785	16,710
20,88,720	3,48,120	6,96,240	4,079	40,790	3,36,320	1,550	9,300
68 86,800	11,47 800	22 95.600	34 316	3 43,160	27,45,280	4,335	26 010
2,40,22,260	40,03,710	80 07,420	21,525	2,15,250	17,22,000	15,375	92,250
1,38,94,200	23,15 700	46,31,400	12,450	1,24,500	9.96,000	8,993	53,358
1,32,14,340	22,02 390	44 04,780	11.841	1.18,410	9,47,280	8,458	50,748
51,87 780	8,64,630	17,29,260	4,649	46,490	3,71,920	3,320	19,920
26,29 440	4,38 240	8,76,480	2,356	23,560	1,88,480	1.643	10,098
2,26,31,220	37,71,870	75,43,740	20,270	2,02,790	16,22,320	14,484	86,904
24,57,000	4,09,500	8,19,000	2,202	22,020	1,76,160	1,572	9,432
43,36.740	7,22,790	14,45,580	3,886	38.807	3,10 880	2,776	16,656
89,52,480	14,92,080	29,84,160	8 022	30,220	6,41,760	5,730	34,380
9,73,25,460	1,62.20,910	3,24,41,820	87,210	8,72,100	69,76.800	62,291	3,73,740
13,41,32,580	2,23,55,430	4,47,10.860	1,55,512	15,55.120	1,24,40,960	89,701	5,38,206
3,59,35,200	59,98.200	1,19,78,400	32.200	3,22,000	25,76,000	23,000	1,38,000
5,03,89,560	83,98,260	1,67,96,520	58,957	5,89,570	47,16,560	32,353	1,94,118
22 04,57,340	3,67,42,890	7,34,85,780	2,46 669	24,66,690	1,97,33,520	1,45 054	8,70,324

TABLE XVI—(*concld.*)

Shown-anticipated yield and income from the various crops to be put in the Bhakra Project areas, as a result of canal irrigation, annually,

Name of the Tracts in each zone according to State	Value @ Rs. 22/-/- per md. (Rs.)	Vegetables & archards		Total Area under Rabi crops.	Total Value State wise.
		Area in acres.	Value @ Rs. 500/-/- per acre. (Rs.)		
1	40	41	42	43	44
A. PUNJAB. ZONE NO 1 RESTRICTED PERENNIAL					
1. Pehowa Tract	13,61,976	2,063	10,31,500	1,03,176	
2. Khanna Samrala Tract	3,86,760	697	3,48,500	34,875	
3. Bist Doab Tract	10,69,200	2,250	11,25,000	1,12,500	
4. Ruper Nangal and South of Patiala Tracts (Ambala District)	2,27,964	480	2,40,000	23,283	
TOTAL	30,45,900	5,490	27,45,000	2,74,534	
ZONE NO.II NON-PERENNIAL					
1. Grey Canal Tract	3,67,620	1,193	5,96,500	64,253	
2. Ludhiana Jagraon Tracts (north of Abohar Br. between Kotla and Bhatinda Br. and North of Bhatinda Br.)	2,04,600	345	1,72,500	18,555	
TOTAL	5,72,220	1,538	7,69,000	82,808	
ZONE NO. III PERENNIAL					
1. Rori Chautala Tract	20,29,500	3.691	18.45,500	2,12,179	
2. Tohana Rangoi Tract	11,73,876	2,135	10,67,500	1,22,722	
3. South of Sirsa and Fatehabad	11,16,456	2,030	10,15,000	1,16,717	
4. Barwala Extension Tract	4,38,240	797	3,98,500	45,822	
5. South West of Hissar Tract	2,22,156	404	2,02,000	23,225	
6. Sirsa Br. & Old Ghaggar Canal area (Karnal Hissar District.)	19,11,888	3,476	17,38,000	1,99,891	
7. Muktsar Hithar	2 07,504	377	1 88,500	21,701	
8. Ferozepore including Sirhind Canal Extension.	3,66,432	666	3,33,000	38,305	
9. Areas where water allowance is to be improved. (F.Z.P.)	7,56 360	1,375	6,87,500	79,073	
Total	82,22,412	14,951	74,75,500	8,59,635	
TOTAL A. PUNJAB.	1,18,40,532	21,979	1,09,89,500	12,16,977	43,75,90,867
B. RAJASTHAN	30,36,000	5,520	27,60,000	3,17,400	11,67,25 000
C. PEPSU.	42,70,596	8,247	41,23,500	4,54,512	16,66,70,431
GrandTotal (A+B+C)	1,91,47,128	35,746	1,78,73,000	19,88,889	72,03,86,298

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SUMMARY FOR THE WHOLE PROJECT

	Area to be Cultivated in acres	Total Production		Total Value in rupees.
		In maunds	In Tons	
KHARIF				
Fodders	5,08,517	8,15,47,050	29,12,395	4,86,77,775
Sugarcane	1,03,741	41 49,640	1,48,201	4,14,96,400
Cotton	7,00,593	70,05,930	4,67,062 Bales	21,01,77,900
Rice	43,872	8 77,440	31,377	78,96,960
Ground nuts	12,136	1,45,632	5,201	14 56,320
Other Food grains	2 10,780	21,07,800	75,279	1,68,62,400
Vegetables and Orchards	35,745	...	...	1,78,72,500
Total	16,15,384	...	...	34,44,40,255
RABI.				
Fodders	3,36,657	8 72,41,440	31,15,766	9,87,35,055
Wheat	12,24 763	1,83,71,445	6,56,123	22,04 57,340
Other Food Grains	2,46,669	24,66,690	88,096	1,97,33,520
Oil Seeds	1,45,054	8,70,324	31 083	1,91,47,128
Vegetables and Orchards	35,746	...	...	1,78,73,000
Total	19,88 889	...	...	37,59,46,043
Grand Total.	36,04,273	...	...	72,03,86,298

Note :- Adding value of 1,20,063 bales of cotton (18,00,945 mds. Kapas) to be produced in Punjab, Pepsu States on account of increase in irrigation due to improved water allowances in Sirhind Canal areas which are already irrigated. 5,40,28,350

Total 77,44,14,648

Say 78 Crores rupees.

TABLE No.

Area irrigated during Kharif and Rabi each year in a holding of Project area, Total produce and

3 Irrigation zones with tracts under each of them.	Total area to be cropped annually	KHARIF CROPS AREA, Green Fodder Area in acres	Yield at 150 mds. per acre (mds.)	Total value @ -8- As. per md.	Area in acres
ZONE NO, 1 RESTRICTED PERENNIAL.					
1. Pehowa Tract	5·63	0·80	120	60	·20
2. Khanna Samrala Tract	5·63	0·68	102	51	·22
3. Bist Doab Tract	5·63	0·78	117	59	·45
4. Ruper Nangal and south of Patiala Tracts (Ambala District)	5·63	0·78	117	59	·45
ZONE NO. II NON-PERENNIAL					
1. Grey Canal Tract	8·42	1·35	203	102	0·34
2 Ludhiana Jagraon Tract (North of Abohar Branch between Kotla & Bhatinda Br. and North of Bhatinda Br.)	8·42	1·26	189	95	·34
ZONE NO. III PERENNIAL.					
1. Rori Chautala Tract	7·75	1·08	162	81	0·12
2. Tohana Rangoi Tract	7·75	1·08	162	81	0·19
3. South of Sirsa and Fatehabad	7·75	1·08	162	81	0·12
4. Barwala Extention Tract.	7·75	1·08	162	81	0·19
5. South West of Hissar Tract	7·75	1·08	162	81	0·19
6. Sirsa Branch and old Ghaggar Canal Area.	7·75	1·08	162	81	0·12
7. Muktsar Hithar	7·75	1·08	162	81	0·12
8. Ferozepore including Sirhind Canal extension.	7·75	1·08	162	81	0·12
9. Area where water allowance is to be improved.	7·75	1·08	162	81	0·12

XVI A.

12 5 acres in different tracts of each irrigation zone of Bhakra annual income for each holding.

YIELD AND VALUE IN RUPEES

Sugar cane		Cotton			Rice			Ground	
Yield of Gur @ 40 mds. per acre (mds.)	Total value @ at Rs. 10/- per md.	Area in acres	Yield of Kapas @ 10 mds. per acre (mds.)	Total value @ Rs. 30/- per md	Area in acres	Yield @ 20 mds. per acre (mds.)	Total value @ Rs. 9/- per md·	Area in acres	Yield @ 12 mds. per acre (mds.)
8·0	80	·42	4·2	126	0·40	8	72		
8·8	88	·36	8·6	108				1·01	12
18 0	180	·68	6·8	204					
18·0	180	·68	6·8	204					
13·6	136	·59	5·9	177	0·84	17	153		
13 6	136	1·36	13 6	408	0·63	13	117	0·21	2·5
4·8	48	1 86	18·6	558	0·39				
7·6	76	1·08	10·8	324		8	72		
4·8	48	1 86	18·6	558					
7·6	76	1·70	17 0	510					
7·6	76	1·70	17·0	510					
4·8	48	1·86	18·6	558					
4·8	48	1·86	18·6	558					
4·8	48	1·86	18·6	558					
4·8	48	1·86	18·6	558					

TABLE No.

Area irrigated during Kharif and Rabi each year in a holding of Project area, Total produce and

KHARIF CROPS AREA, YIELD AND VALUE IN RUPEES									
nuts	Other food grains					Vegetables and orchards			
Total value @ Rs. 10/- per md.	Area in acres	Yield @ 10 mds. per acre (md.)	Total income @ Rs 8/- p. md.	Dry fodder @ 25 mds. per acre	Value @ Rs. 2/- per md.	Area in acres.	Value @ Rs. 50/- per acre	Total area under kharif crops	Total value kharif
...	0·62	6·2	50	16	32	0·06	30	2·50	450
120	0·17	1·7	14	4	8	0 06	30	2·50	419
	0·53	5·3	42	18	26	0·06	30	2·50	541
	0·53	5·3	42	13	26	0·06	30	2·50	541
	1·18	11·8	94	30	60	0·08	40	4·38	762
25	0 50	5·0	40	13	26	0·08	40	4 38	887
	0·30	3·0	24	8	16	0·08	40	3 44	767
	0·62	6 2	50	16	32	0·08	40	3·44	675
	0·30	3·0	24	8	16	0 08	40	3·44	767
	0·39	3·9	31	10	20	0·08	40	3·44	758
	0·39	3·9	31	10	20	0·08	40	3·44	758
	0·30	3·0	24	8	16	0·08	40	3·44	767
	0·30	3·0	24	8	16	0·08	40	3·44	767
	0·30	3·0	24	8	16	0·08	40	3·44	767
	0·30	3·0	24	8	16	0 08	40	3·44	767

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SUMMARY: Annual income from a holding of 12·5 acres in:—
(i) Restricted perennial zone = Rs. 1081/-/-
(ii) Non-perennial zone = Rs. 1529/-/-
(iii) Perennial zone = Rs. 1588/-/-

XVI A —Contd.

12·5 acres in different tracts of each irrigation zone of Bhakra annual income for each holding.

RABI CROPS AREA, YIELD AND VALUE IN RUPEES.									
Green Fodder			Wheat					Other Food	
Area in acres	Total yield @ 150 mds. per acre (mds.)	Total value @ Rs. -/8/- md.	Area in acres	Total yield @ 15 mds. per acre (mds.)	Total value @ Rs. 12/- per acre.	Bhusa @ 30 mds. per acre	Value at Rs. 2/-/- per md.	Area in acres	Total yield @ 10 mds. per acre (mds.)
0·56	84	42	1·87	28	336	56	112	0·32	3 2
0·68	102	51	1·91	29	348	58	116	0·22	2·2
0·45	68	34	1·91	29	348	58	116	0·48	4 8
0·45	68	34	1·91	29	300	58	116	0·48	4·8
0·21	32	16	1 68	25	456	50	100	1·90	19·0
0·21	32	16	2·53	38	492	76	152	0 88	8 8
0 78	117	59	2·71	41	492	82	164	0 43	4·3
0·78	117	59	2·71	41	492	82	164	0 43	4·3
0 78	117	59	2·71	41	492	82	164	0·43	4·3
0·78	117	59	2·71	41	492	82	164	0·43	4·3
0 78	117	59	2·71	41	492	82	164	0 43	4·3
0·78	117	59	2·71	41	492	82	164	0·43	4 3
0·78	117	59	2·71	41	492	82	164	0 43	4·3
0·78	117	59	2·71	41	492	82	164	0 43	4·3
0 78	117	59	2·71	41	492	82	164	0·43	4 3

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TABLE No. XVI A.
(Concld.)

RABI CROPS, AREA, YIELD AND VALUE IN RUPEES.

Grain	Oil seeds			Vegetables and orchards				
Total value @ Rs. 8/-/-	Area in acres	Total yield @ 6 mds. per acre (mds.)	Total value @ Rs. 22/- per mds.	Area in acres.	Value @ Rs. 500/- per acre	Total Area under Rabi crops	Income in Rabi	Total income Kharif plus Rabi
26	0·32	2	44	0·06	30	3·13	590	1040
18	0·26	2	44	0·06	30	3·13	607	1026
38	0·23	1	22	0·06	30	3·13	588	1129
38	0·23	1	22	0·06	30	3·13	630	1129
								Av. 1081
152	0·17	1	22	0·08	40	4·04	778	1392
70	0·34	2	44	0·08	40	4·04	833	1665
								Av. 1529
34	0·31	2	44	0·08	40	4·31	833	1600
34	0·31	2	44	0·08	40	4·31	833	1508
34	0·31	2	44	0·08	40	4·31	833	1600
34	0·31	2	44	0·08	40	4·31	833	1591
34	0·31	2	44	0·08	40	4·31	833	1591
34	0·31	2	44	0·08	40	4·31	833	1600
34	0·31	2	44	0·08	40	4·31	833	1600
34	0·31	2	44	0·08	40	4·31	833	1600
34	0·31	2	44	0·08	40	4·31	833	1600
								Av. 1588

on different running canals in the Joint Punjab. The Crop Planning Committee's estimates are based on the patterns now evolved as a result of a series of deliberations of the Committee of experts, keeping in view the factors given in para 5 of Chapter II, page 11 of the report.

(*iv*) *Total income for a holding of 12½ acres* The total income of a peasant proprietor owning a holding of 12½ acres has been calculated for each of the three irrigation zones and is given in table XVI A. The annual gross incomes come to Rs. 1081/-, Rs. 1529/- and Rs. 1588 - for the Restricted Perennial, Non-Perennial and Perennial zones respectively.

9. Demonstration Farms.

In order to convince the cultivator regarding the usefulness of the recommended patterns a chain of Demonstration Farms should be established for ten years at the rate of one Farm in each tract or sub-tract having distinct agrog-eographic identity of its own. Each of these farms will be 50 acres in area. The land will be taken on lease. The supply of water will be on the same terms as to other share holders of the outlet i.e. no concession will be given, so that the farmer may be able to compare the out-turn in his land with the out-turn in the demonstration farm.

One experienced Research Assistant fully qualified in the subject will be put incharge of the Farm. He will look after the agricultural operations and management of the farm and grow Kharif and Rabi crops according to the pattern recommended for the tract A portion of the Farm will be occupied by the crop pattern and the remaining portion would be used for carrying out various crop experiments connected with the different methods of irrigation for conservation of water with a view to find out ways and means of avoiding water losses.

These farms being scattered in individual tracts will be within an easy reach of the farmers of concerned tracts who could easily visit the farm and see for themselves the usefulness of the crop patterns being tried there. He can also have an opportunity of discussing the details regarding various agricultural operations with the Research Assistant incharge who in turn, can also see the reaction of the farmers and forward his problems for solution to the higher authorities if and when needed.

The publicity of these methods should also be made through the printed leaflets in all popular languages through the Public Relations Department, the Radio and other agencies

CHAPTER III

WATER CONSERVATION

1. Lining of Canals, Branches, Distributaries & Water Courses.

Bhakra Dam is being constructed by the Government at a very heavy cost and so, water to be delivered therefrom being very precious, must be economised to the maximum extent so that the same may be used to the best advantage. All sources through which loss of water takes place should, therefore, be tackled and losses checked. It has been ascertained that out of the total quantity of water that enters a canal at head 17% is lost by way of absorption and evaporation in the main canal and branches, 8% in the distributaries and minors, and 20% in the water courses. This means that for every 100 cubic feet of water received in the field 182 cubic feet of water is released at the head. It has been further found that even out of this 100 cubic feet put in the field only 70 cubic feet, is utilized by the crop plants and the remaining 30 cubic feet is lost by way of absorption in regions below the root zone of the crops. So, out of the 182 cubic feet of water that enters a canal hardly 70 cubic feet is utilised for crop production and the remaining 112 cubic feet of water largely goes under ground to add gradually to the subsoil water table which due to lack of suitable underground drainage goes on rising and induces waterlogging accompanied by all its disadvantages. The matter being serious the authorities have been devoting considerable attention to this problem from time to time, and have been carrying on research both in irrigation agriculture and construction engineering. Consequently the lining of new canals and their branches is now generally under-taken as a matter of settled policy if funds available permit this. The committee investigated the question of lining of the water courses with some suitable, cheap and easily available material which should stop all seepage of water through this source. Out of all the materials tried, mixture of 20 to 25% cowdung and 75 to 80% local soil appeared to be the most suitable and the cheapest material for lining. The lining should be thin to avoid cracks. The sprinkling of silt on the freshly lined surface till it dries up helps to prevent developing of cracks which must be avoided at all cost. The committee recommends that this type of lining first be tried on Government farms so that its utility may be further confirmed and it may serve to demonstrate. the method of lining to the cultivators who should be persuaded to take up the work of lining their own water course in this manner, by explaining to them the advantages to be derived by such adoption. A lot of publicity and propaganda will have to be done for popularising the lining of water courses and effecting the desired change to the largest possible extent.

2. Experiments on improved Methods of Irrigation : –

As explained in the foregoing paragraph about 30% of the irrigation water given to the field, is lost by absorption. This huge loss of precious water can be stopped only if the farmer takes to improved methods of irrigating his crops. But he can do so only when he is acquainted with the definite methods that he should adopt, and before arriving at definite conclusions a lot of research will have to be carried out on various aspects of the problem by the Director, Irrigation and Power Research Institute The chief problems to be investigated are :—

(i) To ascertain the optimum quantity of irrigation water which is required by more important crops for their maturity without wasting any amount thereof. This, in turn will further depend on so many other factors like nature of soil, rainfall and manure.

(ii) To ascertain the optimum size of sub plots for irrigation, for different types of soils and climates.

(iii) To determine the number of irrigations into which the total optimum water supply for a particular crop should be divided, and the time of each irrigation.

(iv) To find effectiveness of different manures for conserving irrigation water to be applied to a particular crop, because previous researches have shown that a manured crop can be matured with lesser supply of water than that required by an unmanured crop. Later, these experiments can be coordinated with the work of the Central Standing Advisory Committee of the Government of India.

There are other devices of irrigating the crops for effecting economy of irrigation water. For example "RAINGUN" an over-head propeller for irrigating crops, is said to be extensively used in Brazil, Germany and other countries. Similarly the 'SPRAY IRRIGATION' is also gaining ground in some other countries as one of the cheapest water saving method of irrigation. The committee recommends that the experiments on spray irrigation should be initiated in an experimental farm in Hissar District for working out the details of this method and its economics under conditions in that district.

3. **Use of Fertillizer for economy of water :—**

The past experience of the Punjab Agriculture Department on the basis of the irrigation and manurial experiments carried out at Risalewala, District Lyallpur, shows that an application of 40 lbs. of nitrogen per acre in the form of sulphate of ammonia saved 6 inches depth of irrigation water in case of cotton crop. Similarly an application of 25 lbs of nitrogen per acre to a wheat field gave normal yields with one irrigation only, thus saving 3 to 6 inches depth of irrigation water. These conclusions had also been corroborated by the results of similar experiments carried out in U.S.A. and Canada. It is, therefore, essential that the fertility of the irrigated fields in the Bhakra Project areas should be kept up at a very high level which besides giving increased production of crops will effect considerable saving of precious irrigation water which can be utilized in irrigating larger areas. This useful recommendation of the Committee should also be given wide publicity in order to make it popular among the growers.

CHAPTER IV

SOIL IMPROVEMENT

(Commonly known as Land Reclamation)

Introduction

In chapter II it is mentioned that approximately 30% of the area surveyed suffers from the trouble of sodium salts and alkali and requires improvement. This type of soil includes the following two categories.

(i) Area having high salt content or high pH value (alkalinity) near the surface......5,32,200 acres.

(ii) Area having high salt content with or without high pH value at some depth within first 10 feet from the surface...... 4,61,400 acres.

On the introduction of canal irrigation, sodium salts react with the clay component of the soil and cause further damage to land. To prevent this further damage, it is necessary that the excess of salts should be removed in the very beginning and lands improved and made fit for normal cropping.

A new feature of land deterioration in the Bhakra area is the presence of sodium carbonate in alkaline soils of Karnal dirtrict. It is well-known that the improvements of these sodium carbonate soils (black alkali soils) is more difficult and expensive.

Experiments are in progress in the Irrigation Research Institute at Amritsar and the experimental farms at Indri and Nissang to determine the most effective and economic method of improvement of this type of land. The results so far obtained are encouraging. It is thought that by the time the actual work is taken up in the field, the technique of improvement will be further perfected to enable operations to be undertaken on a large scale.

For the ordinary thur type viz: soils in which sodium sulphate and sodium chloride are the predominant salts, methods of improvement are already known and trained and experienced staff who have migrated from West Punjab are available with the Director of Irrigation and Power Research Institute.

2. Execution of Soil Improvement : –

Experience in the West Punjab shows that if soil amendment is not undertaken in the beginning of the project and the development of the area is allowed to proceed without a scientific method the whole of the water supply is fully utilized and it becomes exceedingly difficult later on to find additional water for leaching etc. A number of other difficulties arise, such as the working of short period warabandis, the additional engineering works required to supply extra water supplies, the supervision of a large number of operations that have to be carried out strictly according to time table, the most complicated system of land tenures and the agreements made with the tenants, absence of actual landlords from their estates and the obstacles and hindrances presented by some lazy and obstinate shareholders or tenants. To overcome all these difficulties, it was realized in the West Punjab that a new Act was necessary. With that end in view a separate Legislation Sub-Committee was formed. This Sub-Committee has, as a result of its deliberations brought out a new draft Bill, the details of which are given in Chapter V. It is relevant to mention here that after partition, a similar Act has also been passed by the West Punjab (P) Government.

3. Agency for Soil Improvement :—

The Committee have given considerable thought to this subject and have come to the conclusion that in the first place every encouragement should be given to the land owners whose lands are Thur, to improve them under the guidance of trained staff. If, however, the original owners are unwilling to undertake improvement or are not able to excute the work in a satisfactory manner, the Committee recommends that such lands as are declared Thur affected should be requisitioned and given on lease to Co-operative Farming Societies for carrying out improvement operations. Recent experience in the construction of Bhakra Canals has shown that Labour Co-operative Societies have worked very successfully, both to the advantage of the Government and the labourers.

Whenever land is requisitioned for amendments and given to Co-operative Societies, the original owner will be given compensation which will be determind by a Committee consisting of legislatures, Canal and Revenue Departments officials and proprietors' representatives

Provision for this has been made in Section 11 of the proposed Soil Improvement Bill.

4. Blocks of Deteriorated Land :--

As a preliminary to the carrying out of soil improvement either by the original owner or by Co-operative Farming Societies, in case such lands are requisitioned, it is essential that such land should first be divided into suitable sized blocks so that it may be possible to make all arrangements for detailed soil surveys, water supplies for leaching and growth of rice, provision of adequate staff to supervise soil improvement operations etc. On the recommendations of the Committee, the Director, Irrigation & Power Research has gone into this question in considerable detail and has prepared plans of suitable blocks and proposals for improving Thur lands in these blocks These proposals are now under consideration with the Administrative Department. The Committee recommends to Government that early sanction should be given to these proposals, so that deteriorated land in the project is improved in the pre-Bhakra stage as far as possible when it is easier to find water supplies for leaching and growing of rice. Later, when all the irrigation channels are dug and the demand rises to the maximum, it would be exceedingly difficult to undertake any improvement and the trouble of salts and alkali will continue for ever.

5. Costs of Soil Improvement :

The parties concerned are :—

(i) Land owners who agree to carry out soil improvement themselves ;

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(ii) Land owners whose lands are requisitioned for purposes of improvement and given to Co-operative Societies.

(iii) Co-operative Farming Societies.

(iv) Government.

(*i*) *Land owners who agree to carry out soil improvement operations themselves* :—

The work of improvement of thur and alkaline land has been in progress since 1940 and careful costing accounts were maintained for all types of estates viz :—

(a) When improvement is undertaken by land owners who are also the tillers of soil.

(b) When land as in (a) is improved with the help of tenants at will

(c) When land is improved by a landlord in a compact block on a contract supply of water.

These accounts showed that soil improvement leaves a profit even in the first year to tenants, landlords and also to government. The government provides the extra water and the supervisory staff. In return the government gets extra return in the form of water rate and land revenue which will be sufficient to cover the establishment charges. In addition, the gain to the owners is the considerable increase in the value of land which becomes fit to carry a normal pattern of cropping

(*ii*) *Land owners whose lands are requisitioned for purposes of improvement and which land is given to Co-operative Farming Societies.*

It has been mentioned already that such land owners will be given due compensation which will be determined in the manner described. This compensation will be a net gain to the owner. Regarding establishment charges to Government the case is similar to No. (i) supra

(*iii*) *Farming Co-operative Societies* :—To make soil improvement successful with the help of Co-operative Farming Societies, it is most essential that the Societies should not be out of pocket. Rather they should derive some reasonable profit out of this business. The procedure that the committee recommends is that from the results of analyses of soils, the supervising staff should determine the period of years required for the completion of improvement of the soil. It is considered that if the lease is extended to the period of years required for completing improvement and an extra two years are added, it will leave sufficient profit to the Co-operative Farming Societies. If, however, the Government feels satisfied that the Co-operative Societies have really suffered a loss, they may take steps to extend the period of lease.

(*iv*) *Government.*

In the domain of soil improvement, Government has to provide : –

(a) Water supplies for leaching etc.

(b) Supervisory staff for the guidance of the soil improvement agency and the enforcement of the provisions in the Soil Improvement Act.

Past experience shows that the water rate and land revenue obtained from blocks of land taken up for improvement is sufficient to meet the costs incurred by government.

A contingency may arise when neither the owner of land nor a Co-operative Society is forthcoming to undertake soil improvement, may be on account of very advanced stage of deterioration. In that case, provision has been made in Section 14 of the Soil Improvement Bill for government to undertake improvement of such blocks with their own staff employing direct labour, mechanical power etc. The Government will retain such land for a period sufficient to recover the expenditure incurred by it in the same manner as it allows Co-operative Societies to retain the land for longer periods.

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CHAPTER V

SOIL IMPROVEMENT BILL

As indicated in Chapter IV the Committee has strongly recommended that the reclamation of 9,93,600 acres of saline and alkaline land should be taken up as soon as the supply in the Bhakra Canals is available. To implement this recommendation the Crop Planning Committee set up a Legislation Sub-Committee for suggesting some suitable legislative measure so that the Government may accomplish the work of land reclamation efficiently by doing away with some difficulties and obstacles which had been generally experienced during the course of reclamation operations in the joint Punjab. This step was considered essential because past experience has shown that left to his own talent and resources the Punjab peasant has been unable to protect the soil against natural forces which tend to deteriorate his land and consequently Government help is essential for protecting land which is a national heritage. Legislation Sub-Committee held 11 meetings and as a result of their deliberations the required legislation in the form of Soil Improvement Bill was drafted. This has been accepted by the Crop Planning Committee.

It is recommended that this bill may be passed by the State Legislature and put on the Statute Book so that its provisions may become effective during the coming summer season when reclamation operations are to be started. The draft bill is produced below: -

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"Bill to provide for the improvement of soil damaged or likely to be damaged by Thur and Sem."

Whereas it is expedient to make provision for better reclamation of land damaged or likely to be damaged by Thur and/or Sem, it is hereby enacted as follows :

Preamable

1. (a) This Act may be called 'The Punjab Soil Improvement Act, 1954';

(b) It extends to the whole of the Punjab;

(c) It shall come into force on such date or dates and in such areas as the Government may by notification declare from time to time.

Definitions. 2. (*i*) *Canal* includes

(a) all canals, channels, tubewells and reservoirs constructed, maintained or controlled by Government, or under the provisions of this Act for the supply or storage of water;

(b) all works, embankments, structures, supply and escape channels connected with such canals, channels or reservoirs;

(c) all watercourses as defined in clause (ii) of this section;

(d) any part of a river, stream, lake or natural collection of water, or natural drainage channel to which the Local Government has applied the provisions of this Act.

(*ii*) *Watercourse*—means any channel which is supplied water from a canal or any other source constructed under provisions of this Act but which is not maintained at the cost of Government, and all subsidiary works pertaining to any such channel.

(*iii*) *Drainage work*—includes escape channels from a canal, dams, weirs, embankments, sluices, groins and other works for the protection of land from flood, waterlogging or from erosion, formed or maintained under the provisions of this Act.

(*iv*) *Commissioner*—means a Commissioner of a Division, and includes any officer appointed under this Act to exercise all or any of the powers of a Commissioner.

(*v*) *Collector*—means the head revenue officer of a district and includes a Deputy Commissioner or other officer appointed under this Act to exercise all or any of the powers of a Collector.

(*vi*) *Superintending Canal Officer*—means an officer exercising general control over a canal or portion of a canal.

(*vii*) *Divisional Canal Officer*—means an officer appointed under this Act to exercise control or jurisdiction over a canal or any part thereof and includes an officer appointed under this Act to exercise all or any of the powers of a Divisional Canal Officer.

(*viii*) *Sub Divisional Canal Officer*—means an officer exercising control over a sub division of a canal and includes an officer appointed under this Act to exercise all or any of the powers of a Sub Divisional Canal Officer.

(*ix*) *Prescribed* means prescribed by rules made by Government, under this Act from time to time.

(*x*) *Thur*—means soil which is affected by salt efflorescence at or near the surface, making the surface white, ash coloured, black or brown, or not discoloured but presenting an oily appearance, thereby rendering the land unfit for normal cropping.

All lands locally known as Kallar, Shor, Reh, Bara, Rakkar will be classed as 'Thur' for the purpose of this Act.

(*xi*) *Sem*—Land will be classed as 'Sem' if owing to excessive sub soil moisture it becomes unfit for normal cropping and where the context so permits "Sem". "Sem land" or "Sem affected land" means land or area affected by "Sem" and includes such land or areas as may by notification be declared as "Sem" from time to time.

(*xii*) *Improvement of Soil*—means rendering 'Thur' and 'Sem' lands fit for normal cropping and includes preventive measures necessary for avoiding increase of Thur and Sem.

(*xiii*) *Government*—means the Punjab Government.

(*xiv*) *Cooperative Society*—means society registered under Co-operative Act.

(*xv*) *Chak*—The block of land which a canal outlet irrigates.

Power to enter and survey, etc.

3. Any officer or other person acting under the general or special order of a 'Divisional Canal officer', may enter upon any lands in which soil improvement is proposed and undertake surveys or levels thereon; and dig and bore into the sub soil, take soil samples, and make and set up suitable land marks, level marks, and water gauges; and do all other acts necessary for the proper prosecution of any scheme relating to the reclamation of those lands under the charge of the said Canal Officer.

Notice of intended entry into courts or gardens

Provided that, if such Canal Officer or person proposes to enter into any enclosed court or garden attached to a dwelling house not supplied with reclamation water he shall previously give the occupier of such dwelling house, court or garden at least seven days' notice in writing of his intension to do so.

Compensation for damage caused by entry.

In every case of entry under this Section the canal officer shall tender compensation for any damage which may be occasioned by any proceeding under this Section; and in case of dispute as to the sufficiency of the amount so tendered, he shall forthwith, refer the same for decision by the Collector, and such decision shall be final.

4. Whenever it appears expedient to the Government that improvement of soil is required for a certain area, it may notify its intention to improve the said area in the official gazette stating therein the process of soil improvement and such other details as it may consider necessary. hereafter called 'Soil Improvement Scheme' or 'Scheme'.

The Scheme shall also be published for general information in the manner prescribed.

5. Any person whose lands are situated in such areas, who has objection, if any, to the scheme, may apply in writing to the Divisional Canal Officer giving details of his lands, and his objections, together with reasons for the same, within sixty days from the date of the notification in the official gazette or 40 days from the publication of the scheme whichever is later.

6. After expiry of the period specified under Section 5, and after considering the objections received from the land owners or after making such further enquiry as it may deem necessary, Government may modify the Soil Improvement Scheme or such other details as it will consider desirable.

7. The Government shall after such enquiry or modification, if any, notify in the official gazette the final Soil Improvement Scheme.

8. The Divisional Canal Officer shall issue notices to land owners to carry out the Soil Improvement Scheme.

9. After receipt of notice under Section 8 all land owners or occupiers, whose lands are included in the scheme under Section 6, shall be liable to carry out, within a period to be specified, the orders issued by the Divisional Canal Officer, from time to time, under this Act. Any irrigation carried out in contravention of the orders so issued shall be deemed to be unauthorized irrigation for the purpose of Sections 33 and 34 of the Northern India Canal and Drainage Act No. VIII of 1873.

10. Notwithstanding any law to the contrary in the case of:-

(a) Those lands which lie in the area notified under Section 4 and whose owners do not agree if so required to carry out the scheme, or

(b) Those lands whose owners fail or neglect to comply with the orders passed by the Divisional Canal Officer under Section 8 to carry out the Scheme, the Collector on a requisition from the Divisional Canal Officer shall take possession of such land to carry out the Scheme.

Payment of Compensation.

11. Where any land is taken possession of under Section 10, there shall be paid an annual compensation to the land owner. Such compensation shall be determined in the manner prescribed.

12. Any party aggrieved by any such order as to compensation shall have a right of appeal within 30 days of the order to the Commissioner, whose decision shall be final.

Lease of land by Divisional Canal Officer.

13. Where the land has been taken possession of under Section 10, the Divisional Canal Officer may lease it to any person or co-operative society on such terms and conditions as may be approved by the Superintending Canal Officer.

Provided that the period of the lease shall not exceed by more than two years than the number of years that in the opinion of the Superindending Canal Officer are likely to be taken to carry out the said Scheme.

Government may carry out soil improvement operations.

14. Where leasing of the land, taken possession of under Section 10 is not considered feasible Government may itself carry out the Scheme

Delivery of possession on termination of lease.

15. (1) Where any land, taken possession by the Divisional Canal Officer under Section 10 is, on the expiry of the period for which it was taken over, or earlier, (if Government may so direct), to be returned to the owner, the Divisional Canal Officer may ask the Collector to return the said land. The Collector may after making such enquiry as he considers necessary in this behalf specify by an order, in writing, the owner to whom the possession of the land shall be given.

(2) The delivery and possession of land to the person specified in any order made under sub-section (1), shall be a full discharge of the Collector from all liability in respect of such land delivered but shall not prejudice any rights in respect of the land which any other person may be entitled by due process of law to enforce against the person to whom the possession of land is so delivered.

(3) Where the person to whom possession of any land is to be given cannot be found and has no agent or other person empowered to accept delivery on his behalf, the Collector shall cause

a notice to be affixed on some conspicuous part of the land declaring that the land is released.

(4) On issue of the notice referred to in sub section (3), the land specified in the notice shall be deemed to have been delivered to the person entitled to the possession thereof, and the Government or lessee shall not be liable for any compensation or other claim in respect of the land for any period after the said date.

Enforcement of orders by Collector.

16. The Collector may take or cause to be taken such steps and use or cause to be used such force, as may, in his opinion, be reasonably necessary for securing compliance with any order made by him under section 10 and 15 of this Act.

Powers of Canal and Revenue Officers to summon persons

17. (1) The Divisional Canal Officer or the Collector may summon any person whose attendance he considers necessary for the purpose of any business before him under this Act.

(2) Any person so summoned shall be bound to appear at the time and place mentioned in the summons, in person or if the summons so allows, by his recognised agent or legal practitioner.

(3) The person attending in obedience to the summon shall be bound to state the truth upon any matter respecting which he is examined or makes statements, and to produce such documents and other things relating to any such matter as the summoning officer may require.

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Penalty for failure to attend in obedience to order of Canal & Revenue Officer.

18. If a person required by a summons, notice, or order or proclamation proceeding from a summoning officer to attend at a certain time and place fails to comply with the requisition, he shall be liable, at the direction of the summoning officer, to a fine of rupees twenty, which if not paid in cash, shall be recoverable as arrears of land revenue.

Bar the Jurisdiction of Civil Courts.

19. Any order made or action taken in, exercise of any power conferred by the Act shall not be called into question in any Civil Court.

Indemnity.

20. No suit, prosecution or other legal proceedings shall lie against any person in respect of anything done or intended to be done in good faith under this Act or the Rules made thereunder.

Power of Government to make rules.

21. State Government may from time to time make or amend rules to regulate or provide for the following matters :-

(i) Construction, improvement, alteration, extension or curtailment of any watercourse.

(ii) Alterations in irrigation chaks

(iii) Transfer of any area from one source of irrigation to another.

(iv) Irrigation facilities, temporary increase or decrease of water allowance to any area or total stoppage of water supply.

(v) Amendment or cancellation of any order already in force or the issue of a fresh order superseding any existing order or mutual agreements, in regard to distribution of water on any watercourse.

(vi) Prohibition of the growing of any crops or cultivation of any particular crops or laying down any specific crop rotation or use of any particular type of seeds.

(vii) Application of any type and quantity of manure, whether green, artificial or farm yard.

(viii) Layout and construction of any drainage works such as seepage drain covered drain, any other of drainage or other anti-water logging measures.

(ix) Manner of publication of the Soil Improvement scheme as provided in section 4, or issuing of notices under this Act.

(x) To determine the conditions of leases to be given under this Act.

(xi) And generally to carry out the provisions of this Act

Such rules shall be published in the official gazette and shall have, thereupon, force of law.

CHAPTER VI

FERTILIZER REQUIREMENTS

Introduction :

Taking the total cultivated area of the Indian continent and the total population, area cultivated comes to less than 1 acre per inhabitant. In some of the other countries the data is, U.S.A. 3.13 acres per inhabitant, Argentina 5·30, Canada 7·65. In general, it may be stated that a country enjoys a high standard of living derived from agriculture, when more than 3 acres per inhabitant are cultivated. Combined with this a comparison should be made of the yields per acre in India and other countries. The following are the yield :—

		Wheat	Rice
1.	Egypt	1918 lbs.	2988 lbs.
2.	Japan	1713 ,,	3444 ,,
3.	China	898 ,,	2133 ,,
4.	India	600 ,,	750 ,,

These figures at once drive the committee to the conclusion that the only solution is to increase the production per acre. Taking Japan as an example, the area per farming capita is about 1/6th of that in West Germany, 1/10th of that in France, 1/19th of that in U.S.A. and yet domestic production of food and other articles in Japan is 80% of the requirements. This is the result of the tremendous use of fertilizers. The per unit use of fertilizers in Japan is about 10 times the amount for the same comparable unit in U.S.A. or Europeon countries. If therefore, production is to be raised, fertilizer industry should be given top priority. Its importance cannot be over-emphasised.

2. Fertilizer requirements of India :

The annual cultivated area of India is approximately 2660 lac acres out of which nearly 500 lac acres i.e. only 19% area is served with irrigation channels and the remaining land is cultivated by other means.

Besides, construction of several multipurpose projects is in hand in various parts of the country and on their completion 145 lac acres of new land will be brought under cultivation. Areas proposed to be irrigated by each project are given below:

S. No.	Name of Project	Approximate area (acres)
1.	Nangal Bhakra	58,83,000
2.	Hirakud Dam	4,49,000
3.	Damodar Valley	11,41,000
4.	Tunga Bhadra	7,00,000
5.	Kakra Para	6,52,000
6.	Lower Bhawani	2,07,000
7.	Kitsana Pannar	42,00,000
8.	Chambal Hudel	12,00,000
		1,45,32,000

say 14·5 million acres.

In addition, 70 lac acres will be irrigated with the help of tanks, wells, and other means on the completion of First Five Year Plan, besides the area to be brought under cultivation by tube-wells. Another 40 lac acres of land which had previously gone out of cultivation, will be reclaimed and 15 lac acres of new land will be broken for the first time and brought under cultivation by the Central Tractor Organization.

Thus, in all approximately 770 lac acres will be the area under cultivation when all the above stated projects have been successfully completed.

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Out of the present 500 lac acres of irrigated area only 269 lac acres were put under wheat, rice, cotton sugarcane, groundnut and other Kharif cereals in 1952-53. These are the crops to which a dose of fertilizers in generally applied. For this area 125 lac tons of ammonium sulphate will be required.

Presuming that the areas actually put under different crops in each of the states of India, will more or less form the basis for crop patterns to be followed in the areas proposed to be irrigated in the respective states with the exception of the Nangal Bhakra Project area, for which suitable crop patterns have already been evolved. 145 lac acres out of the total of 270 lac acres, will be put under the wheat, rice, cotton, sugarcane, groundnut and other Kharif cereals which will require a dose of fertilizer. For these crops 65 lac tons of ammonium sulphate and 13 lac tons of superphosphate will be needed.

Apart from the above figures considerable quantity of fertilizer will be required for the areas to be included in Second Five Year Plan. Because the figures for this Plan are not yet available even approximate quantities for those new areas cannot be calculated.

It is, therefore, quite obvious that the present annual production of the fertilizers is far short of the requirements of even new areas, not to speak of already irrigated areas of the country which also stand in dire need of artificial inorganic measures for raising their crop yields from the existing low standards.

Once the Indian farmer becomes fully fertilizer-minded in years to come the existing factories will prove quite inadequate to meet the fertilizer demands of all the states. As an example the case of Punjab State is quoted. In 1952, approximately 6000 tons of ammonium sulphate were utilised for manuring. In 1953, 13,000 tons of this fertilizer were utilized. In 1954, 26000 tons of ammonium sulphate have been allotted to this state and it is expected that whole of it will be consumed. At this rate, it is anticipated that when the Bhakra Project Area is fully developed the total consumption of ammonium sulphate will be of the order of 8,30,000 tons of which 1,93,994 tons will be utilized in the Bhakra Project Area alone.

Even if the production capacity of the existing factories is raised so high as to meet the requirements worked out above the movement of the fertilizer to every nook and corner of the country will tell heavily on the available rolling stock. The wear and tear will be tremendous, which in turn shall affect the market price of the commodity. In order to save money and make the fertilizers as cheap as possible so that they become attractive to the farmer, it is essential that at least four fertilizer factories should be established in India—one in the North, one in the South, one in the East and one in the West. In the East, Sindri Fertilizer Factory already exists. In the North, it should be in the Punjab.

3. Fertilizer Requirements of Punjab :

As stated above, for whole of Punjab State 8,30,000 tons of ammonium sulphate are required annually. The present quota of the fertilizers in thus far too short of the requirements even for the new areas proposed for irrigation in the Punjab. To this may be added the fertilizer demands of the areas to be irrigated by Bhakra Canals in the adjoining states of Pepsu and Rajasthan.

The factory proposed to be located in the North will serve whole of the Punjab including the existing canals and the rest of the area in the Punjab, Pepsu, west of Uttar Pradesh, Himachal Pradesh and Kashmir.

4. Selection of a suitable fertilizer :

The Punjab soils suffer from a deficiency of nitrogen and hence respond quickly to the application of nitrogenous fertilizers. The following nitrogenous fertilizers are commonly used :

S. No		*Percentage of nitrogen contents.*
1.	Sodium Nitrate	16·0
2.	Ammonium sulphate	20·5
3.	Ammonium Nitrate	35·0
4.	Nitro Chalk	15·5
5.	Liquor Ammonia	40·0
6.	Ammonium Phosphate	18·0
7.	Urea	46·0

To study the suitability of different fertilizers like urea, ammonium nitrate, ammonium phosphate, ammonium hydro-oxide etc. and their comparative effects on the yield of crops, large-scale experiments have been laid out throughout India. In Punjab state some 800 different experiments in different districts have been started this year by the Agricultural Department. Experiments on three fertilizers are on large-scale, and on other fertilizers e.g ammonium phosphate and triple superphosphate are on small scale in Nilokheri and Nawanshahar Community Project area. The results of these experiments will be available after 2 or 3 years. To educate the cultivator about the usefulness of the fertilizer the Agricultural Department has laid demonstration plots on cultivators' fields. However, it is visualised that in view of scarcity of gypsum, absence of phosphatic rocks in the Punjab, high temperature prohibiting the the use of liquor ammonia and existence of abundant supply of lime stone in the Punjab and absence of any residual effect on the soils, the most probable fertilizer which should be manufactured in the Punjab State is urea. But the Committee feels that the type of fertilizer that should be manufactured in the Punjab, should be determined after the results of the large-scale field experiments are available in the course of next 3 years.

It is relevant to mention here that all the experimental work on manures and fertilizers that has been carried out in the past in the State, has been based either on the availability of the particular fertilizer or on the response on the application of that fertilizer by a particular soil. No attempt has so far been made to determine the fertility status of the soil itself, its deficiencies and its needs for any particular type of manure or a combination of fertilizers from detailed chemical analyses. This is largely because a scientific soil survey of the soils of the State has not yet been carried out. In the absence of a soil survey, difficulties have also been experienced in making assessments at the time of settlements. Had a more intimate knowledge of the soils of the province been available, it would have been relatively easy to assess the fertility status of any soil and its requirements for manure and fertilizers. The Committee, therefore, suggests that a scientific soil survey of the State should be carried out to gather comprehensive data regarding soil conditions of each tract. This will enable a quick decision in deciding on the types of fertilizers required to restore soils to normal fertility immediately after deficiencies are noticed. As the problem is of considerable magnitude, the technical and laboratory resources of any one department may not be sufficient to complete the survey single-handed. It is suggested that the resources of both the Irrigation Research Institute and the Agricultural Department should be utilised to accomplish this important task.

5. Method of Distribution :

Distribution of fertilizers among the cultivators should be according to a well planned system whereby the required quantity of fertilizer is made available to the farmer at proper time at the cheapest rates by reducing all items of incidental charges to the minimum The Department of Agriculture, Revenue and Co-operative Societies should coordinate their activities for ensuring a most suitable method of distribution. System of advancing taccavi loans to needy farmers like the taccavi for purchase of seed and bullocks etc. should be followed in case of fertilizers also. The demands of the cultivators of each Agriculture Inspector's Circle should be calculated and forwarded to the District Agriculture Officer who in consultation with the Revenue Assistant should work out the demand of the whole district after consolidating the Inspectors' demands. Then the quota of the state for fertilizers should be divided among all the districts and allocation for each district communicated to the District Agriculture Officers who would distribute the district quota among the Inspectors. The Inspectors will divide the fertilizer among the village Panchayats or Co-operative Societies who should bring the manure from the source on the strength of a permit issued by their Inspector and honoured by the authority at the source.

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CHAPTER VII

EFFECTS OF IRRIGATION

1. A description of the tracts in the Bhakra Canals area has been given in Chapter II. Out of 33,04,200 acres surveyed, 9,93,600 acres are in a state of deterioration due to the presence of excess of salts or alkali and 3,00,000 acres are excessively sandy. The likely effects of irrigation on this area would be :—

(i) The texture of the soil will undergo considerable change.
(ii) The THUR land will be reclaimed, and
(iii) The excessively sandy soils will be staunched with silt and thereby become fit to produce crops.

2 A provision of new irrigation of nearly six million acres of land in Punjab Pepsu and Rajasthan and with the additional water allowance given to nearly four million acres of Punjab and Pepsu on the Sirhind Canal, would usher in a new era of prosperity and plenty in these States.

It has been estimated that the Bhakra Canal System, when fully developed, will produce the following commodities annually.

Foodgrains	11·3 lac tons
Sugarcane	5 lac tons
Pulses & oilseeds	1 lac tons
Dry & green fodder	16 lac tons
Cotton	8 lac bales

Nowhere in the past has such a vast area been brought under irrigation by a single Project and, therefore, such a vast return achieved. In the wake of this production and generation of 2,88,000 Killowatt of electricity will crop up a large number of industries. With the power available this part of the country will not only become self-sufficient itself and advance both regarding food and industry, but will also help India achieving self-sufficiency to a great extent. This would be a unique development of the tract, and there would spring up a large number of markets, industrial and commercial towns, with a network of roads and other easy means of communication connecting the different parts. Villages will also be industrialised. Famine would disappear from this area for ever. As a result of electrification of the whole country, people will take to cooking by electricity. This will save large quantities of fuelwood now used for that purpose. More trees will remain on the land.

This will encourage more rainfall and thereby improve the climate. With the development of irrigation and forestry, the dread of the march of desert from the south west will vanish. The very severe climatic and weather conditions now experienced in this tract will become mild. In short, the large number of difficulties experienced by the inhabitants of this tract will be replaced by conveniences and comforts and the tract will hum with activity. Even such a bare necessity as drinking water which had to be carried in certain parts from as far as 30 miles will now be available easily.

3. While considering this new era of prosperity and plenty one cannot overlook the adverse effects that are likely to become manifest as a result of canal irrigation over a period of years unless timely action is taken. These adverse effects have been the cause of ruin of many areas in the past both in India and elsewhere. The chief adverse effects are :

(i) Rise in water-table causing waterlogging.

(ii) Thur formation accompanied by structural deterioration of soil.

(iii) Increase in malaria.

It is essential that these points should not be lost sight of in the midst of the great advantages that are in view. Though in large tracts in the Bhakra Canal System the water-table is very low, it is necessary to keep the rise of water-table under close observation. The adverse effect of the rise of water-table in some of these areas may be felt after a long time, but the trouble is bound to come. It is, therefore, very necessary to plan before-hand in order to check the incoming of these adverse or evil effects.

4. Measures to control the Adverse Effects :

Causes contributing to the rise of water-table are :—

(a) Excessive irrigation.

(b) Seepage from canals, distributaries and watercourses.

(c) Presence of impervious strata below the surface.

(d) Lack of proper drainage.

Both from the point of view of waterlogging and maximum income from the available canal supplies, it is essential that only optimum quantity of water should be applied to crops.

Experimental work is already in progress in order to determine the most effective and economic use of available canal water supplies. The Committee, however, think that this experimental work should be extended to almost all tracts so that the optimum quantity of water required for each crop in each tract could be ascertained with certainty. It is also proposed that the results of these experiments should be demonstrated at the proposed experimental farms.

To prevent seepage losses, some of the Main Canals and Branches in the Bhakra Project area have already been lined. It may be possible to further extend the lining to smaller channels. The owners of watercourses should also be encouraged to line them.

The presence of continuous underground impervious strata may hold up considerable quantities of water and cause rise in subsoil water-table. Investigations to locate exact depth of such impervious ridges are already in progress in the Irrigation Power & Research Institute, Punjab, and proposals are under consideration to further intensify and increase the work on this subject.

Lack of storm water and subsoil water drains is probably the greatest factor leading to the rise in water-table and thereby to water-logging of the area, and needs an immediate attention of the Government.

The rise of water-table should be controlled when it reaches a certain limits by intercepting it with drains. Suitable drains have to be provided immediately the rise comes within that limit. Otherwise even drastic steps, such as provision of tube wells and stopping of irrigation facilities adopted later will not be able to check the evil.

In the Joint Punjab the problem of drainage was dealt with in a haphazard manner and funds for drainage were provided in small amounts, with the result that although a huge sum had been spent, yet an efficient and connected drainage system to control the rise of watertable was not provided and the water-table continued to rise at the average rate of one foot per year in the Chaj and Rechna Doabs.

5. Recommendation :

The committee is of definite opinion that in areas other than Khadar areas immediately a rise in water table is noticed in a tract 20 feet of natural surface a programme of construction of dams should be drawn up.

The actual construction of drains should be taken in hand in such tracts so that it does not rise to within 15 feet from the natural surface.

In quite large areas in the State the subsoil water is already within the danger zone. There seepage drains will have to be excavated. The work of excavating these drains should be taken in hand immediately.

It is the firm view of the Committee that boundary roads must be constructed along all drains in order to ensure by inspection that they are functioning properly.

Since the work of the maintenance of drains is very unpopular with departmental staff special facilities for the field staff should be given.

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CHAPTER VIII

Establishment of Mills, Factories, Workshops for Utilising Agricultural Produce.

In chapter VI the anticipated fertilizer requirements of the State have been worked out on the basis of which a case has been made for the establishment of a fertilizer factory in the State. The use of the fertilizers along with the additional area that will come under irrigation will lead to a considerable increase in the production of food grains, American cotton, sugarcane, etc. For the processing of such a large produce it would be essential to instal a number of factories. In this Chapter the factories that are most essential have been dealt with, each case supported by relevant data.

1. Fertilizer Factory :—

Consideration for the location of the Fertilizer Factory. For deciding the location of a plant, the following main factors have to be taken into account :—

(a) Source of energy.
(b) Availability of raw materials.
(c) Consumers' Market.
(d) Miscellaneous facilities like housing, workshops etc., etc.

(*a*) *Source of energy* :—Whatever may be the nature of the fertilizer to be manufactured, in all cases ammonia will be the first product For its manufacture lot of electrical energy is needed, which will be available from Nangal-Bhakra Project. The nearer the plant to the source of energy, the less will be the transmission costs and also losses will be the less. Taking this fact into consideration, the plant may be located at Nangal, where other facilities like housing, workshop etc., are also available as after the completion of the Bhakra Project the existing housing accommodation, will be vacated by the staff working on the Project and this will be available for the staff of another project.

(*b*) *Availability of Raw Materials:*—The raw material required for urea manufacture that has to be transported to the works is lime stone, as water and air for the manufacture of ammonia are available everywhere. No lime stone has so far been explored near Nangal. From the sources so far explored, lime stone is available near Surajpur, where Bhupendra Cement Factory is already in operation. If the urea production plant is located at Nangal, there will be a recurring expenditure for the transport of lime stone from a site somewhere near Surajpur to Nangal, but if the plant is located at or near Surajpur, then the problem of transport of lime stone is altogether eliminated. Moreover, at Surajpur, the waste gases coming out of the Rotary Kiln (for burning materials for making cement) which contain a good amount of useful gases can be utilized for the production of Carbon Dioxide, which is the major consituent of the gases coming from the kiln. The factory management may agree to sell these waste gases at a very nominal price and as such very little lime stone will be needed, and that too only in case the waste gases are found insufficient to cope with the demand. The utilisation of waste gases will considerably reduce the cost of the manufacture. However no facts and figures are available to find out, whether the recurring cost of the transporation of lime stone from Surajpur to Nangal will be more or the cost of transmission of energy from Nangal to Surajpur will be more. This point needs detailed investigation, and has been taken up. It is visualised, that the additional advantage of utilising waste gases at Surajpur might out-weigh the cost of transmission or energy from Nangal etc.

(*c*) *Consumers' Market:*—The main markets for the consumption of the fertilizers are comparatively further away from Nangal, which will effect the charges of transportation to different stations on account of railway freight, and consequently the price of the finished product will be affected. This consideration also favours the location of the factory in the Punjab as near Surajpur as possible.

(*d*) *Miscellaneous factors like housing, workshops etc:*—No doubt at Nangal, the capital cost of housing, workshop and many other facilities will be nominal and it will save a lot that way, but this only is a fraction of the total cost and other considerations like availability of raw materials and waste gases, nearness of consumer's market, etc., etc. which will mean sufficient reduction in the price of the finished product, favour the location of the plant at or near Surajpur.

In their preliminary report, the Committee appointed by the Punjab Government in 1951 for this purpose, had worked out an approximate cost of the ammonium sulphate plant with a capacity of 2·7 lakh tons to be of the order of Rs. 12 crores. This cost in the opinion of the General Manager, Sindri Fertilizers and Ministry of Production, Government of India, was considered to be quite rough, and they expressed that it will be much more than twelve crores. It is estimated that a unit with an initial capacity of 4 lacs tons of urea per annum with arrangements to increase the production as the demand increases will be more suitable.

A reference was made to the General Manager, Sindri regarding the cost per ton, annual out-put, cost of installation and working etc., etc. of the Urea Pilot Plant at Sindri Fertilizers. The General Manager has replied to refer it to the Ministry of Production. Matter had since been taken up with the Production Department.

To arrive at the approximately accurate figure of cost of the plant, it is necessary that the preliminary investigations are carried out by some expert firms with regard to size and specifications of the Plant, economics of its working, availability of raw materials, annual out-put, time required for its installation etc , etc.

As the preliminary investigation, preparation of project report and actual installation of the factory will easily take three to four years, it is proposed that this project may be included in the second five year plan of the Punjab State and Government of India may be requested to provide the required funds and other necessary help.

2. Cotton Ginning Factories and Textile Mills :—

Before suggesting about the number of additional Cotton Ginning and Pressing Factories and the Textile Mills in this State, it is worth while to recapitulate the production of cotton which has been achieved to-date, the targets fixed under the First Five Year Plan by the Planning Commission of the Government of India and the targets proposed, under the second five year plan which will commence in the year 1956.

The Planning Commission of the Government of India had suggested that the production in the Punjab State should be increased to 346 000 bales by the year 1955-56. To this figure should be added the production targets for the second five year plan (1956-57 to 1960-61) proposed by this State. The total production at the end of 1960-61 is estimated as follows :—

Year	*Target of Production in bales.*
First five year plan (upto 1955-56)	3,46,000
2nd five year plan	
1956—57	27,510
1957—58	27,510
1958—59	41 990
1959—60	41,990
1960—61	43,000
Total :—	5,28,000

According to the forecast report for the year 1953-54, the production in this State has already been increased to 3,65,000 bales which is 19,000 bales in excess even of the First Five Year Plan target. It may be mentioned that the total production estimates at the end of the Second Five Year Plan are somewhat conservative which is to be on the safe side. In actual practice the production of cotton may be somewhat more than 5,28,000 bales.

(*ii*) *Installation of New Cotton Ginning and Pressing Factories.*

Before suggesting installation of new cotton ginning and pressing factories and textile mills it is also worth while to take into consideration the present cloth requirements of the people of this State. Punjab is already consuming over 3000 lac yards of mill-made cloth each year. The total textile mills viz. Delhi Cloth Mills, Birla Cloth Mills, Bhiwani Mills and Phagwara Mill including a number of other small concerns, produce about 400 lac yard of cloth. There is, therefore a great scope for the utilization of local raw materials and finding ready market in the zone comprising of Punjab, Pepsu, Delhi etc.

Taking into consideration the number of existing cotton ginning and pressing factories in different districts of this State, it has been estimated that there is an urgent need for the installation of the following additional Factories in this State :—

Name of District	*No. of additional factories required.*	*Location*
Rohtak	1	Rohtak
Jullundur	3	Jullundur, Nakodar and Phillaur.
Ludhiana	1	Jagraon

Ferozepore	1	Malaut
Amritsar	1	Raya
Gurdaspur	1	Batala
Total :—	8	

The above factories are needed to cope with the existing production of cotton and they are being installed at some of these places.

In the following table, is given the additional production of cotton which will be obtained after accounting for internal consumption with the provision of canal irrigation in tracts irrigated by the Bhakra Canals. The number of additional cotton ginning and pressing factories to deal with this increased production is also indicated.

District	*Name of Tract*	*Estimated cotton production in bales.*	*No. of additional factories required*
Hissar	Rori Chautala	20,748	4
Hissar	Rangoi Tohana	7,520	2
Hissar	South West of Sirsa and Fatehabad.	18,427	4
Hissar	Barwala extension tract	8,118	2
Hissar	South West of Hissar	3,201	1
Karnal	West of Pehowa	5,068	1
Ludhiana	Khanna Samrala	19,008	4
Ludhiana	Jagraon tract	3,400	
Ferozepore	Grey Canal	9,314	2
Jullundur	Bist Doab	7,776	2
	Total	102,600	23

It is not possible to suggest the probable location of these factories in the various tracts because besides production of cotton, there are also a number of other considerations, as for example, establishment of Mandis, proximity to railway lines and road connections etc.

(xi) Installation of additional textile mills.

The following statement shows the consumption of **cotton by** the 5 major textile mills in Punjab, Delhi and Pepsu :—

Name of State	Year	Number of bales consumed
Punjab and Delhi	1937—38	136,000
—do—	1945—46	172,000
—do—	1946—47	147,000
—do—	1947—48	90,000
Punjab, Pepsu and Delhi	1950—51	118,000
—do—	1951—52	155,000
Total	6 years	818,000

It will be seen from the above figures that the average annual consumption per mill is about 27,000 bales. These mills are already getting their share of cotton bales from the present production of cotton. There is a lot of surplus production of cotton which is not consumed by the local mills. All the surplus production, therefore, finds its way to Bombay, Ahmedabad and Kanpur etc., where the demand is great. Assuming that the production at the end of the Second Five Year Plan will be 5,28,000 bales and ignoring 3,65,000 bales (1953-54 cotton production) to be on the safe side 1,60,000 bales would be available for newly proposed textile mills in this State. These 1,60,000 bales will be sufficient to meet the requirements of about 5 textile mills each consuming about 30,000 bales or say 2 major textile mills each consuming about 80,000 bales.

(*iv*) *Proposed location of Textile Mills.* Carrying cotton to Bombay, Ahmedabad and Kanpur and bringing back cloth for the population increases wear and tear on the country's rolling stock and in addition the absence of factories will increase unemployment in this state. Starting of textile mills in the Punjab is therefore, essential.

All the area commencing from Rohtak and going to Hansi, Hissar, Fatehabad, Sirsa, Dabwali and Malaut will be major cotton-growing tract as judged from the soil and climatic conditions and also owing to the fact that enough water for irrigation purposes will be available This area is considered very suitable for the successful cultivation of 216 F and 320 F long staple varieties of American cotton There are very good prospects for the installation of five textile mills, in the Punjab. Actual location will be decided by Government

3. Sugar Factories :—

Introduction.

Punjab is the second largest sugarcane growing state in the country, its sugarcane area being 3,71,000 acres according to the final forecast for the year 1952-53. Inspite of such a large area under sugarcane which is capable of yielding 3,00,000 tons of sugar, the State has to look to the centre for meeting its requirements of sugar to the tune of about 1,00,010 tons annually. Thus the Punjab is proving a drain on the sugar resources of the country. India imported 2.17 lac tons of sugar from abroad in the year 1953-54 and contemplates to import 7.5 lac tons this year to meet her sugar requirements. The fact and figures given below show that the state of Punjab is in a position to meet the major portion of its demand for sugar, by installing sugar factories in various sugar growing tracts at suitable places.

(*ii*) *Estimated sugar requirements :*—According to 1951 census the population of Punjab was 1.26 crores. It is estimated that after the completion of the Bhakra Dam the undeveloped district of Hissar will develop gradually like the Montgomary district in West Punjab after the introduction of irrigation there. An annual increase of 80,000 in population is anticipated, so Hissar district alone will account for an increase of 80,000 souls by the year 1969. Adding 2,00,000 on account of normal increase in population in rest of the districts, the population of the state will roughly come to 1·36 crores.

According to the scale of ration approved by the Planning Commission per individual which is 1 chhatank of sugar or Gur per day, the total consumption for sugar or Gur in the state comes to 2,77,000 tons in 1969. To estimate the consumption of sugar alone the Indian Central Sugarcane Committee gave in its publication a figure of 1,16,000 tons of sugar consumed by the Punjab State during the year 1950-51 which shows that the actual annual consumption of sugar per capita is 18.7 lbs. This is the highest for any state in Indian Union. These figures are also corroborated by the statistics of sugar consumption of the Rationing Department. With rise in the standard of living the per capita consumption in the Punjab 10 years hence is estimated to increase to 20 lbs. At this rate, the sugar consumption of the state in 1969 will come to about 1,20,000 tons.

In Punjab there is only one sugar factory at Yamuna Nagar which has a capacity of producing 15,000 tons of sugar annually, and as such the annual import of sugar comes to 85,000 tons. This will rise to 1,05,000 tons by the year 1969 if the arrangements for manufacturing more sugar in the state are not made. For meeting this much requirement at least seven more sugar factories each with a capacity of producing 15,000 tons sugar annually should be installed.

From the figures of area under cane, it is apparent the Punjab produces enough cane to feed seven factories but actually it is not possible to instal so many factories. To unable a sugar factory to run on economic lines it is essential that it should have sufficient area of sugarcane within its radius of 15 miles. Measuring each sugarcane growing district with this yard stick, it is not possible to instal seven factories at this stage as is clear from the following figures.

(iii) *Potentialities of Punjab for producing more sugar* :—The cane area figures of different districts in the state on an average during the last three years along with the probable increase on account of new canal irrigation on completion of Bhakra Canals are given below :—

S. No.	Name of the District.	Average acreage for the last 3 years.	Probable increase after completion of Bhakra Project	Total
1.	Hissar	7,000 acres	20,000 acres	27,000
2.	Rohtak.	54,000 ,,	...	54,000
3.	Gurgaon.	12,000 ,,	...	12,000
4.	Karnal.	41,000 ,,	12,200 acres	53,200
5.	Ambala.	48,000 ,,	...	48,000
6.	Hoshiarpur.	37,000 ,,	...	37 000
7.	Jullundur.	40,000 ,,	16,200	56,200
8.	Ludhiana.	23,000 ,,	4,000	27,000
9.	Ferozepur.	16,000 ,,	7,000	23,000
10.	Amritsar.	34,000 ,,	...	34,000
11.	Gurdaspur.	34,000 ,,	...	34,000

A factory required to produce 15,000 tons of sugar would need 2,00,000 tons or 56,00,000 maunds of sugarcane (taking the recovery of sugar from the cane to be 7·5%) from an area within a radius of 15 miles. This much cane would be produced from an area of 16,000 acres (taking 350 mds to be the average yield of sugarcane from 1 acre area). As only 50% of the cane produced in the country generally comes to the factory, the total area of cane within the circle of 15 miles radius should be 32 000 acres. Judging from this standard the possibility of installation of a sugar factory in each of the major cane growing districts to be irrigated from the Bhakra Canals directly or indirectly, is examined hereunder on the basis of the figures of area given above.

Hissar :—Area being limited a sugar factory cannot be installed.

Rohtak :—One sugar factory can be installed at Rohtak, there is enough area to produce sufficient quantity of sugarcane within a radius of 15 miles from the factory. It is understood that Government of India have already granted licence under the Industries Development and Regulation Act 1951 to a co-operative society for the establishment of sugar factory at Rohtak with a capacity of 800 tons.

Karnal :—One sugar factory can be installed at Panipat where sufficient area of sugarcane exists within a radius of 15 miles to feed the factory.

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Jullundur :—There is sufficient cane area which is to increase still further with canal irrigation facilities from Bist Doab Canal. One sugar factory can easily be installed in this district and its location should be at Bhogpur. The sugar factory at Phagwara (Pepsu) will draw most of the cane grown in Phillaur and Nakodar area and the Bhogpur factory will be fed from rest of the cane area of Jullundur district and adjoining area of Hoshiarpur district. It is understood that Government has already sanctioned this factory.

Ludhiana :—Does not suit for a sugar factory in view of the low figure of sugar area.

Ferozepur : -Same as in case of Ludhiana district.

It is clear from the above that there is a possibility of installing three sugar factories in the state, one at Rohtak, second at

Panipat and 3rd at Bhogpur in Jullundur district. With the completion of installation of these factories, Punjab will be able to supply 60,000 tons of sugar from its own resources and will depend only for 60,000 tons from outside. The question of installing more factories can be examined later on after gaining experience on working of the above mentioned three factories.

(*iv*) *Recommendation :*—The Committee, therefore, recommends that three more sugar factories should be put up at above mentioned three places in the state and Government of India may be requested for their sanction at an early date.

Besides meeting the demand of the consumer in the state to a large extent, these factories will create a ready market for the growers' sugarcane which will give them an incentive to develop the cane growing industry. A large number of skilled and unskilled labourers in the state will be employed and thus solve the problem of unemployment to some extent. Further avoidable wear and tear of the rolling stock due to transport of large quantities of sugar from other states into the Punjab will be stopped.

4. Necessity of Technicians and arrangements for their training :—

With the development of land in the Bhakra Project Areas on the introduction of canal irrigation, an all-round development is bound to come. The Punjab peasant, who is now awakened and is quite alive to his new environments, will put in his best efforts to increase his yields from crops by using improved methods of agriculture *viz.*, use of improved seeds, better agricultural implements, suitable artificial fertilizers, and the quickest and the cheapest means of draught power. 23 new cotton ginning factories, 5 textile mills, 3 sugar factories, a fertilizer factory, tractors and other agricultural implements' factories will spring up simultaneously to cater to the needs of the different areas. Obviously, there will be heavy demand for trained mechanics to work in such industrial concerns. Even at present Punjab is short of trained mechanics. The shortage will become still more acute unless the State Government looks ahead and arranges to find out suitable means of meeting this demand.

Of course, it is very difficult to ascertain the exact requirements of technical personnel that will be required in different types of factories which will spring up as a result of increased production of various crops and the availability of Hydro-Electric current from the Bhakra Nangal Project, until and unless a complete and comprehensive industrial survey is conducted. This question is already receiving consideration by the Standing Advisory Committee for Industries in the State and hence the Crop Planning Committee has not gone into the details of this question. However, to have an approximate idea about the number of workmen or the technicians, a survey of some factory area was undertaken by the Senior Specialist Mechanical, Bhakra Canals Administration, at the instance of the Crop Planning Committee. He collected data regarding the number of workmen and the electric power utilized in various types of factories like flour mills, oil mills, saw mills, ice factories, mechanical workshop, hosiery factories, ice candy foundary and workshop, engineering works, printing press, cotton ginning and pressing mills, sugar mills, tractor repairs workshop and railway workshops comprising small medium and large type of factories. From the data so collected, it was estimated that roughly one workman, on an average, will be required for every 1·24 K. W. of electricity power utilized for running the factories, mills and workshops of different types. It is estimated that 2,88,000 K. W. of electric energy will be available from the Bhakra units at Bhakra Dam and the two power-houses on the Nangal Hydel Channel by 1969 for use in the state for various purposes and a considerable proportion of it will be utilized in running mills and factories. On this basis Punjab will require 2,30,000 technicians of different types within the next 15 years by when it is hoped that the entire electric energy will be used in the Punjab. So arrangement should be made to train at least 15,000 mechanics every year, otherwise the pace of industrialisation will be slower. Unless the required number of trained mechanics is readily available the working of the various factories is sure to receive a great set-back, which will ultimately tell upon the normal speed of all-round developments in the area which in turn will create hindrances in raising the standard of living of the people as a whole, on which subject our National Government is pressing so much.

It has also been seen that the type of trained mechanics now available is generally inferior because they get the certificates of competency without actually knowing their job fully well. This introduces an element of inefficiency and bad workmanship which cannot be tolerated any longer.

The problem before the state is the method in which it should be possible to get trained mechanics in order to run the various factories and concerns which will be run with the power generated. The best way to secure this appears to be to start technical training in all the High Schools whether for boys or for girls. From the sixth to the eighth class, the training should be compulsory. In the ninth and tenth classes, it should be optional. Thereafter, they should join special technical institutions for a period of two to three years. Only those should be given jobs as mechanics who possess the certificates with technical education.

It is also hoped that one of the essential activities of the government in course of time will be to provide free and compulsory education The Committee is further of the view that this education will be up to the Matriculation standard, because up to the Middle standard it does not provide sufficient ability for any one educated up to that standard. So if this expectation of the Committee proves to be correct, the result will be that students educated up to the Matriculation standard will become a problem for the Government if they do not keep themselves busy. Technical education will not only thus provide the required number of mechanics for our factories but this training will also help in reducing unemployment. Thus, the provision of technical education in our High Schools will, in addition to increasing the pace of industrialisation, also solve this problem of unemployment which is so important

One of the present problems of the Government is that almost every one studies aimlessly upto to B. A. or M. A. and thereafter some of them start type-writing and become clerks This type of product of the country is most troublesome because for some justifiable reasons they are dissatisfied. Therefore, those who have taken technical education as their subject in the Matriculation classes, and have later been trained in the special institutions for two to three years' mechanical training, they will become mechanics. Some of them will be selected for posts like Foreman etc. Government should take this step as it will help in reducing the number of students going up for education in the Arts Colleges and also will reduce unemployment.

Till the product of these schools is available Government should open special centres for, say a period of 10 years, to give special education and to hold annual or bi-annual examinations to test the mechanics now available in the market. No one should be permitted to be employed as a mechanic until he possesses this certificate. This will be on the analogy of examinations held under the Boilers' Act. The result of this will be that only capable mechanics will run the machinery, unlike the present practice when inefficient men are employed with the result that they damage the machinery causing failure of industrial concerns due to losses caused by avoidable repairs.

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CHAPTER IX.

Cost of the Bhakra Project and how it is proposed to make the Project productive through levy of Betterment fee.

Introduction :—

On partition the population of Punjab (India) was 44% of the total population of the joint Punjab, while the canal irrigated area was only 24% of the total canal irrigated area in the joint Punjab, and thus with a view to rehabilitating the agricultural economy of the Punjab (India) state, the Punjab Government had to undertake the construction of a number of irrigation schemes including the Bhakra Nangal Project. For undertaking new development schemes specially the Bhakra Nangal Project the Punjab State Government require huge funds. For this purpose it had like other states no alternative but to approach the Central Government to finance the irrigation Projects in the State. The Central Government decided to advance loan for this purpose on the condition that the State Government wanting loans for the Irrigation Projects must levy Betterment Fee on lands brought under irrigation on the Projects, so as to reduce the investment on the Projects in these days of high cost and make them financially self-supporting. This principle has been accepted by the Punjab and other states participating in the Bhakra Nangal Project.

2. Total cost of the Bhakra Nangal Project and the share of the Punjab State :—

According to the latest estimate, the total cost of Bhakra Nangal Project will be Rs 157·4 crores as per table given below :—

Unit No. & Particulars			*Cost in crores of rupees.*
(1)	(a)	Bhakra Dam without Power Plant.	62 6879
	(b)	Bhakra Power Plant	4.4664
(2)		Nangal Dam	3.9464
(3)		Nangal Hydel Channel	11.7887
(4)		Nangal Power House	12.2475
(5)	(a)	Re-modelling Rupar Headworks	1.2579
	(b)	Re-modelling Sirhind Canal	4.0005
(6)		Bhakra Canals.	35.5136
(7)		Bist Doab Canals.	4.2567
(8)		Transmission of electric power.	17.2078
		Total	157.3734

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The cost chargeable to Irrigation will be Rs. 123.4517 crores and to Electricity Rs. 33.9217 crores.

This cost will be shared by all the 3 states to be benefitted by the Project namely, Punjab, Pepsu and Rajasthan Governments. The shares of the Punjab will be about 74 crores for irrigation purposes and Rs 20 crores for electricity. Thus the total share of the Punjab portion will be Rs. 94 crores.

3. How to make the Project productive :

To make the Irrigation and the Electricity part of the Project in the Punjab State productive, Betterment Fee to the extent of Ps. 56 crores in proposed to be levied if this amount is paid by the beneficiaries in lumpsum. As the lumpsum payment is beyond the capacity of the owners of the land, it is proposed to realise the Betterment charges in 30 half-yearly instalments by including interest on the due. In that case the total realisation that will have to be made will be about Rs. 73 crores. Rates of Betterment charges that are proposed to be levied on the Bhakra Nangal Project have been calculated keeping in view the following :-

(a) Type of irrigation facilities provided ;
(b) the improvement irrigation ;
(c) the extent of enhancement in value accruing to the lands.

Accordingly the rates have been worked out as below :—

(a) Betterment charges on Barani areas when supplied with perennial in irrigation.	30-half yearly instalments of Rs. 8/- each.	
(b) Betterment charges on Barani areas when supplied with restricted perennial irrigation.	Rs. 5/12/-	—do—
(c) Betterment charges on Barani areas when supplied with non-perennial irrigation.	Rs. 4/8/-	—do—
(d) The Grey Canal areas. These areas are at present receiving inundation supplies, which are not available during sowing period of Kharif and Rabi.		

Now these areas will receive weir controlled supply from 1st May to the end of October. The betterment fee on such areas will be	Rs 2/4/-	—do—
(e) Sirsa Branch area. The existing intensity of irrigation will increase from 43% to 62%. Betterment fee will be payable at	Rs. 2/8/-	—do—
(f) Ghaggar Canals. The irrigation will be from inundation to perennial and the existing intensity of 31% will rise to 62%. The betterment fee will therefore be	Rs. 4/-/-	—do—
(g) Sarusti Canals. The present inundation irrigation will be converted into restricted perennial irrigation and the intensity of irrigation will rise from 21% to 45%. Betterment fee will be	Rs. 3/-/-	—do—
(h) Sirhind canal area on which water allowance is to be increased. The intensity will be increased by about 10.5% and the betterment fee leviable will be	Rs. 1/6/-	—do—

The land owners will not feel any burden at the time of Betterment fee because levy of this fee is to commence one year after the supply of irrigation facilities to the areas concerned and thus the Zamindars will pay betterment fee in instalments as they earn from the land which gets the increased benefit from improved irrigation facilities provided by the project which will result in increasing the crop yields per acre from 50% to 100%.

4. Levy of Betterment charges is not a tax.

Levy of betterment fee is not a tax. The value of land which is to be supplied water from the canal under the Bhakra Project and other projects is bound to increase considerably. The Government propose to get some part of the increase in value of the land so that the loan taken from the Central Government for the Bhakra Nangal Project may be partly repaid. Out of this amount not a single pie will be spent on any other project. This is only a "charge" and not in any way a "tax". It will be realised only from those people who are to be benefitted from the scheme. Furthermore, it will be charged in proportion to the gain accrued. It means that the people who get water for two crops will have naturally to pay more, whereas a lesser amount will be charged from the people who will get less water on account of their lands being in the jurisdiction of restricted perennial or non-perennial area.

5. Betterment levy is necessary to make the project productive and at the same time to repay the loan taken from the Centre.

The income from the irrigated areas of a canal becomes almost steady after a period of ten years from the opening of the canal because the Project gets fully developed by then. In the case of electricity, the development is slow in the beginning. Further, in order to develop industries a low rate per unit of energy should be charged. A low rate however, can be charged only if the capital cost of the project is low.

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Therefore, in order that both irrigation and electricity portions of the project become productive within the period of 10 years from the start of irrigation in the case of canals and the generation of power in the case of electricity, it is necessary to reduce the sum-at-charge of both irrigation and hydro-electric projects as early as possible.

The only way in which this money could be collected is by levying betterment charges, there being no other alternative to reduce the cost of project adequately.

6. Modus Operandi of making the Projects productive:

The betterment charges will be levied on lands served by the project concerned and will be utilized towards reducing the principal and the interest on the irrigation part of the project, till the return is more than the interest payable during the year. This will be possible only from 1959--70 that is 11 years after the completion of the Bhakra Dam in 1959.

The effect of this will be that the capital cost i.e. the loan of the Government of India will be so reduced that thereafter the interest payable every year will be less than the income from both the irrigation and electricity parts of the projects. As mentioned above, the income from the irrigation project will be more or less steady after ten years. With the development of industry, if the income from electricity part of the project increases, we will be able to pay back the entire amount to Government of India.

7. What is Betterment Fee ?

Considering that the value of land will rise as a result of introduction of canal irrigation it is only fair that the owners of land benefitted by the scheme concerned should contribute a part of this un-earned income towards the construction of the project which brings water and subsequent prosperity to the land and its owners. In Section 5 (i) of the Punjab Betterment Act, it has been laid down that the amount of Betterment charges shall not exceed one half of the difference between the value of the land on the pre-project and the post-project dates.

Again in Section 3 of the Punjab Betterment Act it has been laid down that the amount of betterment charges recoverable from any scheme will be limited to the difference between the investment on the scheme and such part of it as may make it productive. No betterment charges should be levied in relation to an irrigation scheme where the charges ordinarily leviable under other laws for the time being enforce are sufficient to recover the cost of scheme,

8. Precedents in West Punjab of Acts similar to the Betterment Charges Act.

Betterment charges were not levied in the case of any of the canals constructed in the Joint Punjab because the capital cost was low, and areas irrigated were large enough to produce high percentage of income.

As, however, the income expected from the Thal Canal constructed during high prices, was not sufficient, the Punjab Thal (Increase in value) Act of 1940 was passed in order to enable the Government to levy a tax on lands which had already appreciated or were likely to appreciate in values as a result of introduction of irrigation in Thal area. The object of that Act was, therefore, similar to that of the Punjab Betterment Charges Act. Thus, even in the Joint Punjab, with good financial position, Government had to levy this tax in order that the capital spent on a particular project should yield revenue more than the interest charges for the year, i.e. in order to make it productive.

In that Act a rate of Rs. 30/- per acre was proposed as the levy of tax or what is described as betterment charges under the present Act. Considering that the cost per acre of land on the Thal Project was As. -/4/- (reference page 101 of Punjab Legislative Assembly Debate Volume XIA), the tax was levied at 120 times the cost of land. It is learnt that this tax has since been raised to Rs. 60/- per acre. Thus the tax on the Thal is 240 times of the cost of land prior to the introduction of the Project.

The above shows that even in the Joint Punjab betterment fee was levied on new development projects and it is not the first time that such charges have been levied in the Punjab (India). This practice of levy of betterment charges is also being followed in other States of India.

9. Precedent in the rest of India of cases similar to the Punjab Betterment Charges Act.

(i) Bombay passed the Act in 1950. The betterment fee is leviable on new schemes only and the charges are fixed at half of the increase in the value of land.

(ii) Hyderabad passed the Act in 1952. The Act provides levy of betterment fee on all works that came into operation after January 1, 1943.

(iii) Pepsu passed the Act similarly on the line of the Punjab Betterment Charges Act, 1952, only last year.

(iv) Madras. The draft bill on the subject is under the active consideration of the the Government. There, the betterment will be leviable on works that came into operation after January, 1943.

(v) Rajasthan, U. P., Assam, Saurashtra and Travancore Cochin. The matter of framing of similar legislation is under the active consideration of the State Governments.

From the above it is obvious that betterment levy will be made not only in this State but other States also have taken or are taking similar action to meet the demands of the high cost of the present day projects.

10. Comparison of present day conditions, i.e. conditions prevailing at the time of construction of Bhakra Nangal Project with those at the time of the construction of the previous projects.

The Upper Bari Doab, The Sirhind, the Western Jumna and the Lower Chenab Canals were constructed when prices were very low. The Upper Chenab, the Upper Jhelum and the Lower Jhelum Canals, were constructed in 1912 when prices, though higher than before, were still 1/6th of those now prevailing. During construction of Sutlej Valley Project, prices had slightly risen but they were even then 1/4th of the present day rates. During the construction of the Haveli Canal, there was a slump as a result of which the rates were again very low. The daily wages for a coolie at the time were -/6/- against Rs. 2/- per head per day at present. The present day prices are at least 4 to 5 times of the highest rates prevailing during the construction of the rest of the canals in the Joint Punjab.

Bhakra Dam is the first storage scheme in the Punjab and first concrete high dam as high as 680 feet in India. The capital cost of this project is, therefore, bound to be high. In fact storage schemes always cost much more than schemes which are fed by ordinary weirs or barrages in the rivers. An additional reason for high cost of Bhakra Nangal Project is that it includes provision for generating electricity on a very large scale. No previous project in the Joint Punjab had such multi-purpose provision.

The Punjab Betterment Charges and Acreage Act, 1952.

The rules issued under that Act, and a note on the procedure for administration of Act, as finally adopted, are given as appendix "C" of the report.

CHAPTER X

Summary

Chapter I

Para 1 of this chapter gives the personnel of the Committee and para 2 the Terms of Reference.

The Committee appointed two Sub-Committees, Legislative Sub-Committee and Crop Planning Sub-Committee, for drafting the Soil Improvement Bill and the proposed crop patterns respectively.

Chapter II

The scientific soil survey of the Bhakra Project areas covering 33,04 200 acres of land spread over ten tracts lying in Ludhiana, Ferozepur, Hissar, Karnal, Ambala and Jullundur districts showed that 9,93,500 acres of land is deteriorated due to Thur and Kallar and requires reclamation before it can be put under normal cropping For the rest of the area i.e. 23,10 000 acres of land, which is free from any trouble, suitable crop patterns have been evolved after taking into consideration the nature of soil of these tracts, their climate including rainfall, depth of subsoil water table type of natural vegetation and tree growth, water requirements of individual crops in the field as well as at the distributary heads, water allowance, capacity factors and intensity of irrigation for different irrigation zones in which the particular tract lies, kharif rabi ratio, size of holding and number of family members. The past experience and the results of crop experiments carried out in the Joint Punjab as well as in other states and countries together with the crop patterns being followed by the cultivators on various canal systems had also been taken into consideration during the course of the deliberations of the Committee.

The method of evolving crop patterns has been laid down and an illustration of working out the crop pattern for south west of Hissar tract is actually given on pages 37 to 40 for guidance

The crop patterns worked out for south-west of Hissar tract, Barwala Extension tract, Rangoi Tohana tract, south of Sirsa and Fatehabad tracts, Rori Chautala tract, Muktsar ithar Sub-tract, West of Pehowa tract, Samrala Khanna tract, Bist Doab tract and Sidhwan Branch or Ludhiana Jagraon tract and Grey Canal tract have been given in detail on seperate sheets in tabular form. These are commended to the cultivators, for adoption on the receipt of canal irrigation through the Bhakra Canal System, for obtaining maximum yields.

To convince the farmer of the soundness of the proposals, it is proposed to open for a period of ten years, demonstration farms with area of fifty acres each at the rate of one farm per tract. The farm at Hissar will be bigger and will have arrangements for demonstrating the use of 'rain-gun.' This latter farm will be permanent.

Chapter III

The necessity of conserving precious canal water has been emphasised and different sources through which losses take place have been indicated. Of 182 cusecs of water entering the canal at head 31 cusecs are lost in main canal and branches, 14·5 cusecs in distributaries and minors and 36·5 in watercourses and only 100 cusecs reach the field. The lining of the water courses with an easily available and cheap material viz. mud and gobri, has been recommended.

As 30% of the supply put in the field is lost through seepage, the Committee has recommended that field experiments to determine the optimum quantities of water to mature different crops should be conducted in various tracts under the supervision of the Director, Irrigation & Power Research Institute.

Similarly best method of applying irrigation water like the the size of the sub-field for economising water should also be ascertained.

Spray irrigation is also a means of saving irrigation water and increasing irrigated areas and the same has been recommended for trial in the demonstration farm at Hissar.

Chapter IV

The extent of saline and alkaline areas, their nature and method of reclaiming the different types along with the agency for reclamation have been given in this chapter. It has been shown that the reclamation of these areas should be taken up immediately so that these may be put under normal cropping for producing good crops.

Chapter V

For facilitating land reclamation operations the enactment of a Soil Improvement Bill has been recommended.

Chapter VI

It was decided by the Committee that for getting the maximum production of crops by raising the fertility standard of the project area soils, the application of nitrogenous inorganic fertilizers was essential. It is estimated that the areas for which crop patterns have been evolved and recommended 1,93,994 tons of ammonium sulphate, which is a popular artificial nitrogenous fertilizer, would be required. As the present factories at Sindri and Alwaye, which manufacture only 4,00 000 tons of ammonium sulphate annually, will not be able to cope with the demands of various states in India including Punjab, installation of three more such factories within the country will be necessary; one in the South, one in the West and the third in the North. The one in the North should be located in the Punjab, where cheap electricity for running the factory would be available and sufficiently large quantity of fertilizers would be needed for manuring the irrigated areas in Punjab, Pepsu, Rajasthan, Himachal Pradesh, Jammu and Kashmir States and West Uttar Pradesh. Establishment of fertilizer factories to serve local areas as described above, will save wear and tear of the rolling stock and will reduce the incidental expenses making the fertilizers to be supplied to the cultivators cheaper thereby. The best method of distributing the fertilizers among the farmers i. e. through the village cooperative societies or panchayats has been recommended.

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Chapter VII

Some of the likely good and bad effects of canal irrigation on different types of land as available in different tracts of the project areas have been discussed. These are as follows :—

(*a*) *Good Effects* :—

- (i) Additional food grains, pulses, oil-seeds, cotton, sugarcane, fodder etc.
- (ii) Rise in prosperity and standard of living.
- (iii) Improvement of climatic and weather conditions.
- (iv) Industrialisation.

(*b*) *Bad Effects* :—

- (i) Rise in water table leading to waterlogging, and deterioration of soil due to *thur*.
- (ii) Malaria.

To prevent the bad effects from coming up, government is advised to take immediate action in providing adequate drainage system wherever the water table has already risen to 20 and above.

In the remaining areas, the rise of water table should be watched and as soon as it rises to 20′ below natural surface, construction of drains should be taken up.

Experiments should be conducted to determine the optimum amount of irrigation water which should be given to various crops to prevent seepage of irrigation water which adds the rise in subsoil water and enhances water logging.

The work of maintenance of drains is unpopular. Staff employed on this work should be afforded special facilities so as to attract able men to this work.

All drains should have motor roads for inspection, otherwise their working cannot be supervised and money spent in construction of drains will be wasted.

Chapter VIII

There will be huge increase in the production of American cotton and for dealing with that increase the opening of five taxtile mills and . 3 ginning factories has been considered essential. Similarly the installation of three sugar factories for dealing with the increased production of sugarcane in the Bhakra Nangal Area and for meeting the demand for sugar in the Punjab State will be necessary.

It has been shown that on the availability of cheap electricity and with the increased production of raw material a number of factories and workshops will spring up gradually along with the development of the area and there will be a huge demand for trained mechanics. Approximately one mechanic will be needed for 1·24 K.W. of electricity and according to this formula Punjab will require about 2,30,000 technicians of different types within the next fifteen years, which gives about 15,000 mechanics every year. It is recommended that the government should take timely steps to make adequate arrangements for training facilities for training the mechanics at various centres under government control to meet the situation, otherwise industrialisation of the State will be slow.

It has been recommended that in order to increase the number of available mechanics in the State as early as possible so that

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the development of industry should not suffer, technical education should be introduced in all schools of boys and girls starting from sixth class upwards. Up to the eighth class, the technical education should be compulsory and there after optional. It should not be necessary for all children of the State to go up for academic education in the colleges. For higher mechanical engineering courses, special additional institutions should be provided after matriculation.

Till such time as the product of these high schools is available, special arrangements should be made to hold proficiency tests of mechanics on the analogy of examination held under the Boilers' Act No one who has not passed the test, should be given a job of mechanic. It is well known that at present a number of inefficient men pass as mechanics.

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CHAPTER XI

Recommendations

Chapter II

The crop patterns evolved by the committee should be taken up by the cultivators in the various tracts of the project area for obtaining maximum profits. The Irrigation Branch should take up the work of demonstrating these patterns among the cultivators by opening experimental demonstration farms at various places in the tracts so that the farmers of different ilaqas may have an easy access to such farms and adopt these patterns in their own fields after convincing themselves about the usefulness of these patterns. This is the best method of demonstrating for popularising a particular method of cultivation among the cultivators. Publicity of these patterns should also be made through the Publicity Department and other organizations by distributing printed leaflets in Hindi, Gurmukhi and Urdu. (Para 9)

Chapter III

The economic use of canal water being very essential, the Committee recommends that all the watercourses should be lined by the zamindars with a mixture of mud and gobri. This material is cheap and will be easily available to the farmer for irrigation. This method of lining should also be practised on the above proposed farm for popularising the same among the farmers in different ilaqas. (Para 1).

Spray irrigation which is a means of economising irrigation water and increasing irrigated area should be given a trial at the experimental farm to be opened at Hissar. (Para 2).

Chapter IV

The reclamation of 9,93,600 acres saline and alkaline areas should be taken up immediately as the irrigation supplies in the Bhakra Canals are available for this purpose. The work should be taken up during Kharif, 1955. (Para 1)

The land to be reclaimed should first be divided into blocks of 25 acres each and reclamation operations thereof should be taken up through the agency of Co-operative Societies of the cultivators themselves by leasing out the blocks for a definite number of years to be determind beforehand. The owners of the lands to be reclaimed should be given proper compensation. The terms of lease to be entered into by the lessee and the Government, the amount of compensation to be given would be determined by a committee consisting of representatives of legislature, local canal and revenue officers and of the owners and the lessees, after inspection of the areas. (Para 3)

4 61,400 acres of thur area is such where salts are at some depth from the surface. Their reclamation being easier and economical should be taken up first and for doing that the carrying out of detailed soil survey on 25 acres grid basis is recommended. (Para 4)

Chapter V

The Soil Improvement Bill drafted by the Committee should be introduced in the next Budget Session of the State Legislature so that its provisions may become effective for taking up the work of reclamation in Kharif, 1955. (Para 1)

Chapter VI

To meet the increasing demand for artificial fertilizers in the Bhakra Nangal Project areas, for its development and the rest of canal irrigated area in the State, a fertilizer factory should be installed in the Punjab, because the existing factories at Sindri and Alwaye will not be able to supply enough fertilizer to the Punjab. The place for location of the foctory and the type of fertilizer to be manufactured therein cannot be recommended at this stage, because the results of large scale field experiments in the Punjab and other States will have to be awaited for taking this decision. (Para 3)

Chapter VII

The construction of drains should be so completed that the water-table does not rise above fifteen feet from the natural surface in areas other than khadir, because once it rises to this zone, the the trouble of thur appearing at the surface will sta·t Therefore,the operations of digging drains must be taken in hand as soon as the water-table has come within twenty feet from the natural surface in a tract lying above the khadir. The Grey Canals tract in Ferozepur district, a part of west Pehowa tract in Karnal district, Bist Doab tract of Jullundur district and Khanna-Samrala tract of Ludhiana district deserve immediate attention in this behalf as in these areas the water-table is already higher than 15′ below Natural Surface. (Para 5)

Chapter VIII

For utilising the increased production of long staple cotton to be produced in the Bhakra Nangal Project areas, an additional number of 23 ginning factories at various places in Hissar, Ludhiana, Jullundur, Karnal and Ferozepur districts will be required. Similarly, the amount of produce of cotton also justifies the opening of five additional textile mills in the State. (Para 2)

In view of an anticipated increase in the sugarcane area the installation of three sugar factories at various places in the sugar growing areas will be necessary. (Para 3)

Even at present there is a shortage of trained mechanics and technicians in the State. With the development of Bhakra Project areas, different types of factories, such as, a fertilizer plant, sugar factories, ginning and textile mills and many other industrial concerns will spring up. They will require a large number of trained mechanics. Shortage of trained mechanics will thus become a bottleneck in the process of industrialisation. The best way to secure trained mechanics will be to start technical training in all the high schools whether for boys or for girls. From the sixth to the eighth class the training should be compulsory. In the nineth and tenth classes it should be optional. After education up to the matriculation standard they will be required to join special institutions for specialisation for two to three years.

This will also provide jobs for quite a number of educated youngmen, who now study aimlessly in the Arts Colleges up to B.A. or M.A. and become a problem for the State.

Till the product of these institutions is forthcoming, Government should open special centres for a period of ten years to give special education as mechanics and hold their tests on the analogy of tests held now under the Boilers Act.

No one should be given the job of a mechanic till he possesses the certificates of proficiency as above.

APPENDIX—A.

Note by Shri R. R. Handa, I. S. E. for the information of the Crop Planning Committee for areas to be irrigated by Bhakra Canals, and on the scope of work to be done by the Committee.

1. **Bhakra Dam Project** :—As a result of the partition, India has particularly lost the whole of its American Cotton growing area. This deficiency must be made up, if we are to be self-sufficient in the production of textiles even of an average fine variety. At present, the mills are importing large quantities of long staple cotton from abroad. We have further to be self sufficient in the production of wheat.

The previous proposals regarding Bhakra Dam Project were actuated by considerations entirely different to those by which we have to be guided at present. Before partition the united Punjab was very well served by its canals and was a surplus province. It was, therefore, considered that all that was necessary was to provide bare subsistence to the Hissar area which was subjected to frequent devastating famines. After the partition, the whole question has to be very carefully considered. The available supplies must be utilised with due regard to the optimum requirements of irrigation in relation to the kind of crops to be raised, rainfall, kind of soil, existing irrigation development and depth of subsoil water level, etc. After very careful consideration of this important question, based on a comparison of the climatic conditions of the tract to be served, with the older canals of the united Punjab the project areas have been classified into three zones.

Zone No. 1. This zone includes the Bist Doab Samrala Rajpura tracts, the tracts south of Patiala, and the Kaithal Pehowa tracts. The area lies nearer the hills, receives good rainfall during the monsoons and moderately good rainfall during the winter months. The tracts are densely populated and the existing irrigation is done chiefly by wells. The spring level is generally 30 to 60 feet below the ground. It is observed to be gradually going down, rendering lift irrigation more and more expensive every year. Barani cultivation is also attempted wherever possible but rainfall is generally deficient during the sowing and maturing periods. Flow irrigation is definitely needed in these tracts, as the population mostly subsists on agriculture, but it would not be advisable to give too liberal a supply and, therefore, restricted perennial supply for these canals has been proposed, to avoid any danger of water-logging and to conserve water for other tracts. Therefore, a low intensity of 45 per cent has been proposed for the area.

These densely populated areas actually require a much higher intensity, probably of the nature of 100 per cent. The balance 55 per cent would be covered partly by percolation wells and deep tube-wells. These will also keep down the water-table, should it show any tendency to come within the danger zone.

Zone II. This zone comprises riverain areas with high spring levels situated close to the river. Most of this area is already receiving inundation canal supply from River Sutlej by the Grey Canal series. The existing supplies although extremely liberal, are limited in duration as the canals cannot be opened till the river rises during the summer months.

The existing irrigation would be cut off after the construction of the Bhakra Dam. Hence it is absolutely necessary to provide irrigation for these areas from Bhakra waters.

It is, therefore, proposed to take off a branch named Sidhwan from Sirhind Canal. A low intensity of 35% is proposed for the zone, but the canals would remain open up to the end of October to give good first watering for the Rabi crops.

Zone No. III. This zone consists of the dry and the arid areas of Hissar and Rohtak districts and areas on the border of the state of Rajasthan.

The rainfall in these areas is very meagre and uncertain, varying from 10 to 15 inches. The spring level is very low, anywhere from 100 to 150 feet below the natural surface. Lift irrigation is impossible. The well water is mostly brackish and drinking water is generally collected in ponds during the rains, or from the outlets of the irrigation channels.

The tract is subject to frequent devastating famines. Two or three successive seasons of timely rainfall may produce enough grain to last a few years, but, on the other hand, two or three successive years of drought may produce actual famine conditions. A very severe famine occurred in the years 1939-41.

Relative to the hills, the tract is situated parallel to the Nili

Bar and Lower Bari Doab canals. The climate is similar, but the rainfall is somewhat superior.

The areas to be included within the irrigation boundry of the project are detailed below :—

Description of the tract	Gross area in acres.	Approximate culturable commanded area in acres.
Zone No. I Restricted Perennial		
Samrala Rajpura.	1,55,000	1,39,500
South of Patiala.	6,590	5,931
Pehowa Tract.	4,58,560	4,12,704
Bist Doab.	5,00,000	4,50,000
Rupar Nangal	1,00,000	90,000
Total	12,20,150	10,98,135
Zone No. II Non-Perennial		
North of Abohar Branch.	70,734	63,661
Grey Canals.	4,25,000	3,82,500
Between Kotla and Bhatinda Branch.	36,560	32,904
North of Bhatinda Branch.	15,440	13,896
Total	5,47,734	4,92,961
Zone No. III Perennial		
Ferozepur District.	23,364	21,028
Muktsar Hithar.	69,890	62,901
Barwala Extension.	1,47,576	1,32,818
South West of Hissar.	74,803	67,323
Tohana Rangi Tract.	3,95,241	3,55,717
South of Sirsa and Fatehabad.	3,75,902	3,38,312
Rori Chautala.	6,83,346	6,15,011
Sirsa Branch Existing.	6,05,667	5,06,416
Sirhind Canal Extensions.	1,00,000	90,000
Old Ghagar Canal area.	86,324	72,978
Total	25,62,113	22,62,504
Grand Total for Punjab	43,29,997	38,53,600

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2. **Soil Survey**. To determine :—

   (a) character of soil to be irrigated,

   (b) the possible effects of surface irrigation,

   (c) The possible quantities of water required for maturing crops, and

   (d) the possible methods by which irrigation water can be conserved and soil fertility maintained, a scientific soil survey of the area to be covered by the project was ordered. The areas already receiving irrigation were not to be surveyed. The rectangulation of the whole of the tract was under-taken and the soil survey was done on grid basis. Each sampling site was to represent 600 acres of land. The samples were to be taken upto 10 feet depth with the help of an augar. Twenty percent of the sites were to be examined by open pits. Some of the sites were also to be examined up to subsoil water-table.

A preliminary rapid reconnaissance soil survey was also undertaken.

The area surveyed was little over 3·25 million acres spread over the districts of Hissar, Karnal, Ludhiana, Ferozepur and Jullundur. The total number of sites examined was 4442 representing an area of 26,65,200 acres. Twenty two profiles have been examined up to water table. The total number of samples collected is 57,000.

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All the samples have been examined for pH, total salts, kankar and clay.

Note:—"pH"—denotes hydrogen—ion concentration. A logarithmic scale of the reciprocal of the hydrogen—ion concentration of 0—14, used to measure the acidity or alkalinity of a substance. Precise neutrality is pH 7.0. If the soil contains alkali (Black alkali) the pH value will be above 8·5 and may exceed 10·0. Acid Soils have pH value below 7·0. Soils of the Punjab plains are generally alkaline i.e. the pH values are above 7·0.

The area examined is not compact and is divided into the following tracts :—

Hissar District

(1) Rori Chautala Tract.

(2) Tohana Tract.

(3) South of Sirsa and Fatehabad Tract.

(4) Barwala Extension Tract.

(5) South-West of Hissar Tract.

Karnal District

(6) West of Pehowa Tract.

Ludhiana District

(7) Khanna Samrala Tract

Ferozepur District

(8) Grey Canal Tract.

Jullundur District

(9) Bist Doab Tract.

pH value (alkalinity) above 9·0, total salts above 0·2% and clay above 17·0% were considered as high for soil fertility and normal yields of crops.

On the basis of analysis, the area has been divided into the following four categories :—

(1) Area having high salt content and high pH value near the surface 4,67,400 acres i e. 17·5% of total area.

(2) Area having high salt content with or without high pH value at some depth in the soil profile 3,04,400 acres i. e. 14·4% of the total area.

(3) Area excessively sandy with normal salt content and pH values 3 30,600 acres i.e. 12 4% of the total area,

(4) Land good in all respects...14,83,200 acres i. e. 55.7% of the total area.

The details of different types of areas in each tract are given in the table attached.

It will be seen that area under sub-head (3) and (4) is equal to 18.13,800 acres. This can be put under normal rotation of crops directly the irrigation facilities are available. In case of 3,30,600 acres of land under sub-head (3) only certain crops can give good yields. Crops with higher deltas are not to be grown in this area as due to seepage losses and percolation, water-table is likely to rise. In category (4) there are also included those lands where clay content is very high. In order to obtain good out-turn of crops some process of improving "tilth" of soil will have to be resorted to.

Note :—"tilth" is that good physical condition of soil which enables it to give a good seed bed, improve its water-holding capacity and effects favourably on the availability of plant food. This happens when the very fine individual particles in a soil combine together to form aggregate particles.

8,51,400 acres included under sub head (1) and (2) are such where reclamation is indicated before the introduction of normal cropping. If reclamation is decided upon it would be much better to allot such lands only after reclamation so that lands may be taken up for reclamation in economical and consolidated blocks without encountering the problem of special wara-bandis and other complications which were normally experienced during the reclamation of privately held lands. In case the lands are proprietary it would be much better to acquire them and hand them back to the owners after reclamation.

In areas relating to category (2), reclamation will be quicker and easier.

The detailed report on the scientific soil survey of the areas to be irrigated by the Bhakra Canals is under preparation and will be circulated separately.

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S. No.	Name of tract	Total area in the tract.	Area examined to date.	Land good in all respect.	Area excessively sandy salt content and pH values normal.	Area having high salts with or without high pH at some depth.	Area having high salts and or high pH value near the surface.
1	2	3	4	5	6	7	8
	HISSAR DISTRICT						
1.	Rori Chautala tract.	6,83,346	5,03,400	2,46,600 48·96%	80 400 16%	1,02,600 20·3%	74 400 14·8%
2.	Rangoi Tohana	3,95,341	3,80,400	1,97 400 51·9%	15.600 4·1%	70,200 18·2%	97,200 25·8%
3.	South of Fatehabad and Sirsa.	3,75,902	3,66,000	1,68,000 46%	1,28 400 35%	43,800 12%	25,800 7%
4.	Barwala Extention	1,47,5[illegible]6	1,53,000	87,600 57·2%	27,600 18%	17,400 11·4%	20,400 14·4%
5.	South West of Hissar.	74,803	72,600	57,800	24,000 33%	10,800 15%	... 0%
	KARNAL DISTRICT.						
6.	West of Pehowa.	4,51,518	4,57 800	2,43,600 53·2%	... 0%	72,600 16%	1,41,600 30·8%
7.	Khanna Samrala.	1,68,632	1,87,800	2,43,600 85 3%	1,200 0·6%	13,200 7%	13,200 30·8%
8.	Grey Canal.	4,25,000	3,55,200	1,84,200 51·8	46.800 13·2%	37,200 10·5%	87,000 24·5%
9.	Bist Doab.	Not known (4,12,200) (from profiles taken)	1,89,000	1,58,400 83·8%	6,600 3·5%	16,200 8·6%	7,800 4·1%
	Total	31,34,318	26,65 200	14,83,200 or 55.7%	3,30,000 or 12·4%	3,04,000 or 14·4%	4,67,400 or 17·5%

APPENDIX B

Scientific Soil Survey of Bhakra Project Area.

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Scientific Soil Survey of Bhakra Project Area.

Synopsis.

An area of 33,04,200 acres of land spread over ten tracts lying in Ludhiana, Ferozepur, Hissar, Karnal, Ambala and Jullundur districts was surveyed. About 5507 profiles each representing 600 acres were taken. Generally profiles were exposed upto 10 feet depth but about 40 profiles were taken upto the water table.

In all 57,178 samples were analysed for total soluble matter, alkalinity, clay and kankar percentage. Selected profiles were tested for chemical as well as mechanical constituents

The Objects of the Survey were to :—

(a) determine the character of the soil to be irrigated.

(b) know possible effects of surface irrigation when canal water becomes available.

(c) estimate the probable quantities of water required for maturing crops.

(d) determine methods to conserve irrigation water and maintenance of soil fertility.

Regarding the standards for good and bad lands :—It was decided that pH values above 9·0, total salts above 0·2 and clay percentage above 17·9 should be considered the factors contributing towards deterioration of land.

Classification of area :—As a result of analysis total area surveyed can be divided into the following four categories.

	Acres
(i) Area having high salt content and or high pH value near the surface.	5,32,200
(ii) Area having high salt content with or without high pH value at some depth in the profile.	4,61,400
(iii) Area excessively sandy with normal salt content and pH values.	3,00,000
(iv) Land good in all respects.	20,10,600

Lands falling under (iv) can be directly put under normal crops when water is available. In some areas certain correctives may have to be applied to counter-act the effect of high clay content.

In 3,00,000 acres under (iii) both irrigation and cropping has to be planned on the basis of actual experiments.

9,93,600 acres included under sub heads (i) & (ii) require regular reclamation before they can be put under normal cultivation.

Hissar District :—In this district there are following five different tracts:—

(a) Rori Chautala tract.

(b) Rangoi Tohana tract.

(c) South of Fatehabad & Sirsa tract.

(d) Barwala Extension tract.

(e) South West of Hissar tract.

Lands of this district are generally light and contain Sodium Sulphate and Sodium Chloride as principal salts. Total area surveyed is 15,75,600 acres. Approximately 31% of the area needs reclamation which will not be difficult. Before definite recommendations are made for the remaining area, experiments will have to be carried out to determine most suitable crop rotation, dates of sowing and irrigation. Soils being light, irrigation shall have to be controlled and deltas must be fixed after experimentation if the risk of water-logging is to be avoided. In such light type of soils maintenance of fertility is again a problem.

Water table varies from 80 to 150 ft. Generally the sub soil water is unfit for irrigation.

Karnal District :—There is only one tract in this district. It is named West of Pehowa tract and comprises of 4,82,400 acres out of which 2,08,800 acres i.e. approximately 43% area is in different stages of deterioration. The soils of the tract are heavier than Hissar District. In considerable area water-logging already exists. The predominant salts are Sodium Carbonate and Sodium bi-carbonate. Due to action of these salts tilth of the soil has been greatly damaged. Reclamation of the district will be difficult and technique evolved in Joint-Punjab needs modifications.

Almost the entire area is capable of giving good yields when injurious effects of salts, alkalinity and clay content are eliminated.

Water-table in the district varies from 0" to 37 feet. Sub-soil water is suitable for irrigation purposes, but at places it is saline.

Ludhiana District :—In this district all the three types of cultivation viz. Barani, well irrigation & canal irrigation is found. Almost 100% area of the district is cultivated. There are two tracts in the district as given below :—

(i) Khanna Samrala Tract.
(ii) Ludhiana Jagraon tract.

Three types of soils namely Dakar, Raunsli and Bhudi type are met with. Bhudi type of soils are suitable for ground-nut cultivation.

Soil crust varies between 2—8 feet in loamy and light loam area. The soils of the district have reached fatigued stage. Maintenance of soil fertility is a major problem in this district. Out of 3,68,400 acres surveyed only 51,000 acres need regular reclamation.

Water-table of the area varies from 6 feet to 35 feet and the sub-soil water is sweet.

Ferozepore District :— There is only one tract in this district named Grey canal tract the area of which is approximately 4,25,000 acres. This is the worst of all the tract. In this tract water-logging also exists. Approximately 1,89,600 acres need corrective measures. In the majority of 1,89,600 acres salts have appeared at the surface. The main salts are Sodium Sulphate and Sodium Chloride. Considerable area is vulnerable to floods during monsoon and thus their fertility is frequently upset.

Pohli grows in abundance both in cultivated and uncultivated fields. Its eradication is itself a problem.

Water-table varies from 0'' to 10' and the sub-soil water is suitable for irrigation purposes. Surface drainage needs careful management.

Jullundur District :—Only one tract namely Bist Doab constitutes the area surveyed in this district. According to No. of soil profiles taken, the area surveyed works out to 4,11,000 acres out of which deterioration is indicated only in 51,000, predominent salts being sodium sulphate and sodium chloride reclamation of deteriorated land will not be difficult. So far no canal irrigation exists in this tract. It would be, therefore, essential as well as useful to study the effects of canal irrigation on soil conditions of this district.

To avoid the danger of water-logging due to prolonged canal irrigation, there is every necessity of controlled irrigation after careful planning.

Another important problem of this district is canalisation of choes which at present cause lot of damage during the monsoon.

The sub-soil water is sweet and fit for irrigation purposes. Water table varies from 11 ft. to 34 feet.

General Suggestions :—

(a) periodical surveys just before settlement operation in each district should be done to serve as check on fertility control of land.

(b) To know the exact extent of deterioration of lands throughout the province soil surveys of the remaining cultivable area of the province may also be initiated so that a regular programme of reclamation of lands may be chalked out.

(c) Experiments both on laboratory and field scale should be started to obtain utmost benefit from the soil with the minimum quantity of irrigation water.

A Report on the Scientific Soil Survey of Bhakra Project Area.

Introduction.

1. A scientific soil survey of the area proposed to be irrigated by the Nangal and Bhakra projects was sanctioned by Government. Field work was started in 1940. Excluding the area already receiving canal irrigation, which is roughly about 6,00,000 acres, the total area proposed to be irrigated by Nangal Bhakra projects works out to approximately 36 lakh acres.

2. This area is spread over six districts of the Punjab viz. Hissar, Karnal, Ambala, Ludhiana, Ferozepore and Jullundur. The total area to be surveyed was a little over 33 lac acres.

3. It was laid down that one profile from every 600 acres should be taken. Soil sampling has been done upto 10 feet depth from the surface. Soil samples have been taken from every foot section. A number of profiles were also exposed upto water table at selected sites in each type of land. From these water-table profiles, moisture samples were also collected to have an idea of the moisture gradient under pre-irrigation conditions. 20% of the profiles were to be taken by pit method.

Experimental.

4 In all 57,178 soil samples were received in the laboratory for analysis. These soils were examined for pH (alkalinity), total soluble matter, clay and kankar percentage. Selected profiles were

also subjected to detailed chemical and mechanical analysis to obtain exact idea about both chemical and physical properties of the soil. A few water samples taken from the different wells were examined for judging their suitability mainly for irrigation.

Object.

5. The object of the survey was to determine :—

(a) The character of the soil to be irrigated.

(b) The possible effects of surface irrigation, when canal water becomes available.

(c) The probable quantities of water required for maturing crops.

(d) Methods to conserve irrigation water and maintenance of soil fertility.

Total number of profiles examined for the above four constituents amount to 5507 which represent 33,04 200 acres from all six districts.

Nangal and Bhakra projects are expected to cost Rs. 156 crores, it is imperative that such dearly available water should be properly and fully utilized to pay a good dividend in the form of water rate and land revenue.

On the basis of the soil conditions and properties the areas to be irrigated have to be classified under different categories so that maximum use of the water is made and no water is allowed to be wasted in the shape of excessive irrigation than what is necessary to mature the crops or leaching down of injurious salts.

Standards for soil fertility and deterioration.

6. In soil surveys of waste lands the limit of pH value is laid at 9·0 for the purpose of determining the advisability of new irrigation projects. It does not mean that lands having range of alkalinity between 7 and 9·0 are not alkaline. In India in matters of standardisation or crop assessments the soil fertility has been stabilized at a lower level as compared to other countries. The range between 7·0 to 8·3 pH values has been given the status of a good normal soil in India and if a piece of land suitable otherwise but has a pH value ranging from 8·5 to 9 0 it is considered to be capable of cultivation directly, irrigation water become available.

7. Before the start of analytical work it was decided that pH values above 9.0, total salts above 0·2% and clay above 17·9%

should be considered high for the soil classification of the area.

8. On the basis of analytical results this area can be broadly divided into following four categories :—

	Classifications.	*Area in acres.*
1.	Area having salt content and or high pH value near the surface	3,32,200
2.	Area having high salt content with or without high pH value at some depth in the profile.	4 61,400
3.	Area excessively sandy with normal salt content and pH values.	3,00 000
4.	Land good in all respects.	20,10,600
	Total	33,04,200

9. Discussion of results

From above figures it is obvious that 23,10,600 acres of land falling under (3) and (4) can be put under cultivation directly the irrigation facilities are available. In type (4) are good lands capable of carrying normal crops on normal water supply and are likely to give normal yields. Such soils have salt content less than 0 2 per-cent and pH value between 8 5 and 9·0 In these soils the yields of crop will tend to go down below normal. Application of corrective measures such as one rice crop followed by a leguminous crop like berseem or senji should form a rule in lands having only pH values between 8·5 and 9·0. After the first year rice can be eliminated from the rotation.

10. As a matter of fact a soil having pH values more than 7·5 is an alkaline soil and can possibly be improved. Generally the soils of Punjab are alkaline. Before any deterioration in soil is visible or some appreciable drop in crop yields is noticeable, the action of sodium salt on the exchange complex goes on which consequently gives rise to progressive increase in the degrees of alkalisation. This increase in the exchangeable Sodium of a soil is responsible for damaging the structure of soil. In Punjab poor soil structure has developed due to cultivation of the alkaline soils over a period of many centuries without any scientific crop rotation. As such the Zamindar has to be contented with relatively lower yields as compared to other countries because the

fertility of our soils have stabilized at lower standards for want of corrective measures. In category (4) the majority of soils are such which possess this stabilized standard of fertility and will give normal yields on the introduction of canal irrigation. In this type (4) there are also included those lands where clay content is very high. In order to obtain good out turn of crops some milder processes of improving tilth of the soil will have to be resorted to.

11. In 3,00,000 acres under sub head (3) only certain crops can be successful in the beginning provided they are sown at proper time. It is just possible that canal irrigation may not be profitable in the type of soil where there is excess of sand throughout the depth of soil profile. It is a matter for consideration to extend canal irrigation to such areas. In the excessively sandy profiles barani cultivation may prove to be more suitable. In areas which respond to canal irrigation care has to be taken that crops requiring larger deltas are not grown as due to seepage losses and percolation through water courses and fields water-table is likely to rise which will create the problem of water-logging. This point has to be kept in mind while crop planning for this area is to be taken up.

In this connection, it will not be out of place, to mention the case of the rise of water-table in the area commanded by Basira Distributary of the lined Haveli canal (West Pb., Pakistan).

Sub soil water levels were observed twice a year in June and October in a number of wells lying on all over the area, but in the Basira area, 23 pipes specially sunk in 1940-41 were read monthly.

The results of the water levels in the wells and pipes are summarised below :—

(i) The sub soil water table had steadily risen in all the pipes, at an average rate of 0·10 foot a month, the total rise from June 1941 to April 1945 being 5·08 feet.

(ii) The rise from month to month was fairly uniform in all the pipes individually and as a whole.

(iii) There was no fall during the winter months.

(iv) There did not seem to be any abatement of the rise of water-table.

(v) To conclude it appeared that the rise of the water-table was mainly due to sandy composition of the soil.

In view of the above facts, we have to suggest special types of crop rotations for such area which would not demand large deltas.

12. 4,61,400 acres falling under type (2) are such where a zone of salt accumulation exists within the pelliicular zone though apparently soils are undeteriorated. Salts are found both in conjunction with alkalinity and alone in these profiles. This type will require regular reclamation. It will be quicker and easier to reclaim the lands in the present stage of deterioration rather than to take them up when salts would have appeared at the surface.

13. If the story of Sheikhupura and Gujranwala is not to be repeated, it is advisable to reclaim the soils before the allotment of land and introduction of normal rotation of crops because with deep irrigation salts are bound to rise to the suface and render the land unfit for cultivation which will not only result in loss of revenue to the state but will also make the zamindars to suffer economically. After the actual appearance of thur at the surface the reclamation will become difficult as well as more expensive and time consuming. In clayey profiles the speed of reclamation will be impeded due to high clay content and will certainly take longer time than profiles having low clay content.

14. Considerable quantities of water will be needed in the beginning to wash down the salts and to sow reclamation crops.

15. 5,32,200 acres are such where thur has appeared on the surface or there are very high pH values at the surface or both are present. This category (1) of land cannot be brought under plough without first reclaiming it. These saline and alkaline soils are difficult and at the same time expensive to reclaim. In some of the profiles pH values are higher than 9·5. These soils are known as 'Rakhar' soils. Reclamation of Rakhar soils takes a much longer period than thur soils. At the time of low agricultural prices it is not profitable to reclaim them but at the present level of agricultural prices it is economical to improve them. Type (1) can be taken after reclaiming type (2).

The extent and location of types having known from this soil survey the amount of water required for reclamation of types (1) and (2) can be calculated. On the basis of these calculations the capacities of distributaries and allowance for these areas should be fixed. The approximate time required for the reclamation of each block of land represented by each particular profile has been given against the result of each individual profile.

16. Thur in all 9,93,600 acres i.e. approximately 30% area needs reclamation.

It is true that the main canals in the Bhakra Project are to be lined, but taking into account the seepage losses through minor irrigation channels, water-courses and fields, rise in water-table can still be expected. Some preventive measures should be taken before the actual irrigation starts in the tracts which do not possess compact sub-stratum.

17. Again, in areas which are very clayey throughout the depth of 10 feet soil profile or more, there is liklihood of false water-table having been formed after some years of canal irrigation. This false water-table is liable to cause a kind of artificial water logging. Steps will have to be taken to ensure that water allowance is so fixed that minimum quantity of water is available for downward seepage. Hence the necessity of careful management and planning for such type of lands.

18. In general Punjab soils are alluvial and the presence of sodium salts is their inherent characteristic. pH values also are on the alkaline side. Even in very good soils it is near about 9·0 and normally it ranges between 8·0 and 8·5.

19. A large number of soil profiles in the Punjab Alluvium in the first 10 feet depth have shown more than one deposits of alluvial soil. This is also confirmed by the fact that more than one zone of salt accumulation are found in the pellicular zone which normally extends to a depth of ten feet under the arid condition of the province.

20. Detailed analysis of selected profiles has revealed that inspite of main characteristics being common in whole of the province, the nature of predominant salts differ from district to district. In some tracts, principal salts are sodium chloride and sodium sulphate and in others sodium carbonate and sodium bicarbonate are found. Moreover, the area surveyed is not compact and can be divided in general terms into following ten tracts situated in different districts

of the State :—

S. No.	*Name of tract.*	*District.*
I.	Rori Chautala Tract.	Hissar
II.	Rangoi Tohana Tract.	Hissar
III.	South of Fatehabad & Sirsa Tract.	Hissar
IV.	Barwala Extension Tract.	Hissar
V.	South West of Hissar Tract	Hissar
VI.	West of Pehowa Tract.	Karnal & Ambala
VII.	Khanna Samrala Tract.	Ambala & Ludhiana
VIII	Ludhiana Jagraon Tract.	Ludhiana
IX.	Grey Canal Tract.	Ferozepore
X.	Bist Doab Tract.	Jullundur

21. To study their peculiar features, it will be only proper to classify individual tract separately and to discuss characteristics of each district.

22. The classification of the areas belonging to each tract is shown in Table 1, appended. Detailed analyses of different tracts are given in Table 3.

23. *Hissar District*—According to the number of profiles received from this district, the total area surveyed works out to 15,75,600 acres. Average rainfall of the district for the last four years is 14·6 inches. Barani cultivation is done on a large area of this district but due to uncertainty of rainfall crop failures are common. If, however, rains are in time then the growth of crops as well as their yields are exceedingly good

24. The soils of the district are generally light and vary between sandy loam and loam with some scattered strips and patches where the clay content is high throughout the depth of soil profile. Maximum clay content met with is 55%. Almost all the area is covered with sand probably wind blown, the thickness of which varies from place to place. Large tracts having a covering of sand or sandy soil,3 or 4 feet deep,will need proper crop planning because excessive irrigation or normal water allowance, suitable for more heavy soils may have harmful effect on the land. It would be doubtful if all the crops will be successful in the beginning even with controlled supply of canal water. The choice of crops has to be made with reference to the thickness of covering of sand and composition of the strata under-neath.

25. The excessively sandy soils may not respond to canal irrigation and it may prove more profitable to bring them under cultivation as Barani. Experiments will have to be carried out, to suggest the best possible crop rotation for such areas.

26. Approximately 31% of the total area surveyed in this district (4,93,200 acres) exhibits deterioration. Salts are as high as 4 5% in village Ganga (Table 5), and they exist at different depths in the soil profiles. Alkalinity in the district is in the range of 7·5 to 10·8. High pH values are found both separately and in conjunction with high salts. In the majority of profiles Kankar is also found. Analyses of few typical profiles are given in Table 2.

27. The predominant salts of the soils belonging to this district are sodium sulphate and sodium chloride which are much easier to reclaim than sodium carbonate and sodium bicarbonate infested soils. Detailed chemical analysis have brought out that in the exchange complex of these soils calcium is still the major and effective base which is rather a complementary factor. It serves as a pointer to the fact that the soils though infested with high salts have not yet reached a stage when reclamation would become extremely difficult. Once reclaimad Hissar soils are bound to give good yields of crops They also contain sufficient quantity of calcium carbonate which is helpful in protecting Iron and Magnesium from being leached down in alkaline soils.

In profiles where high alkalinity exists only in the first few feet of soil, Jantar, gowara or other type of green manuring should precede normal cropping, otherwise cropping in such lands will be insecure and yields will be poor.

It is now well known that organic matter plays an essential role in securing in soil, the structure or tilth, that is needed for high fertility. In fact maintenance of the supyly of organic matter in arable soils is of the greatest practical importance, for productive capacity is largely dependent upon it. Singh and his co-workers (2) investigated the effect of leguminous and non-leguminous crop residues on the fertility values of soils. They recommended the use of leguminous crops for green manuring purposes Their results have been further verified by irrigation and agricultural workers. But the data is still scarce regarding the effect of different types of leguminous crops as fitted in different crop rotation on the fertility of varying types of alkaline soils.

To reclaim deteriorated soils, to get maximum crop production and to maintain soil fertility, it is absolutely essential that water allowances are fixed with reference to soil types and the distributaries are designed accordingly.

28. Out of 15,75,600 acres, 8,41,800 acres are such where normal crops can be taken directly the water is available. There should be little difficulty in fixing the water allowance for this type of land.

29. It has already been stated that timely rains give very good yields. Similarly canal water given at the right time will serve the purpose. A thorough study of existing irrigation practice in Hissar District in combination with rainfall is a necessity to obtain good yields. For this, experiments shall have to be carried out to determine the most appropriate crop rotations, dates of sowing and irrigation both kharif and Rabi crops so that soil fertility is maintained and at the same time good yields are obtained. For culturable commanded area on each separate channel regulation can be carried out on the basis of results of above-said experiments.

30. For maintaining the soil fortility, humus plays an important role. In this district, all the soil organic matter gets scorched during hot days of summer. Farm yard manure is not readily available in large quantities and is therefore expensive. Moreover, it is also liable to be burnt if applied as it is only a surface treatment.

31. One of the methods to keep a regular supply of organic matter in root zones of plants will be under ground green manuring at a depth of about 18 inches. The yields of crops after deep green manuring will increase tremendously and the effect will last for several years. The organic matter added through green manuring improves soil structure and the water holding capacity of the light soils also increases. It is very interesting to point out the results of Bouyouces who showed that the organic matter increased markedly the available water in light soils, and to a less extent that in heavy soils. Even though desert soils as poorly aggregated, the amount of aggregates that is present is provided with the small quantity of organic matter. Humic acid is released which increases norganic soil constituents and also micro organic activity.

Experimental farms should be opened and deep green manuring with Jantar and other leguminous crops should be tried. These experiments will also provide valuable information on further economy in irrigation water. Actually full scale canal irrigation will be started in 1959 and there is ample time to carry out these experiments and to obtain results by then, if the experiments are started in the near future.

It has already been mentioned in the forgoing that water table is expected to rise in comparatively lighter soils on the advent of canal irrigation. At present the water table in the district varies from 80 to 150 feet. To know the quality of water a number of water samples were taken and examined in detail. The analysis indicate that generally the sub-soil water contains high salts and is not suitable for irrigation purpose. Out of 21 water samples only seven were fit for irrigation. The possibilities of having tube-well irrigation in Hissar District was investigated about 13 years back. It was concluded that most of the water samples were highly salines, hence unsuitable for irrigation. But experiments will have to be carried out to investigate the best possible source of green manuring and probable depths at which the green manuring is to be done for different types of soils under varying climatic elements.

32. In a little over half a century the water-table will be within the pellicular zone. The quality of sub-soil water being bad the appearance of water logging will bring with it the tremendous amount of salt that it contains apart from the accumulations which have been found to exist in the soil profile above it. Analyses of soil profiles taken upto water table have revealed the presence of several zones or salts accumulation through out the depth. With the rise of water-table movement of salt towards the surface will be accentuated and the problem faced in the West Punjab will repeat.

33. Now that the water table is deep and the soil profile is relatively dry some preventive measures should be adopted. Vertical tube-wells are not the cure.

34 In this district there are five distinct tracts and it will be of interest to discuss them individually in detail :—

(*I*) *Rori Chautala tract* :—35. It is spread over blocks E 12 D 12, V 11, W 11 and portions of J 12 and K 12 in Sirsa Tehsil of the district. Total area of the tract is 6,83,346 acres. Broadly the tract can be divided into three parts from visual examination. One is comparatively compact and level land on both sides of the River Ghaggar, 2nd, is sandy soil with large number of sand dunes scattered all over and the third is light soil but is level.

In the first type soil varies from loam to clay loam and if free of high salts and high alkalinity it is capable of producing all crops. Kankar is found. Being near the river sub-soil water level varies from 50 80 feet. A water-table profile was dug near the river in village Khaireka. Sub soil water was found to be fit for irrigation purposes. Due to vicinity of the river, considerable portion of land is flooded by river water during monsoon.

36. In the 2nd type of soil kankar is also found in the form of belts. Depth of sub soil water is between 80 and 150 feet. A water table profile was exposed in village Bara Gudha and sub soil water sample was chemically examined. Water is brackish and unsuitable for irrigation purposes. In this type of soil if rains are timely, crops give good yield but generally failures are experienced

37. In the third type crops can be successful with great care. as there is sufficient seepage. In the adjoining areas where there is already canal irrigation crops are successful. To reduce seepage losses the size of the fields has to be decreased so that water reaches all corners of the field without being percolated much in the process.

सत्यमेव जयते

Natural vegetation of the tract is Ak, Karir, Jal, Jand, Chhimber, Buin, Khip and Bhakra.

38. Samples have been take from area representing 5,55,000 acres only out of which 3,48,000 acres need no reclamation. In 82,200 acres deterioration has reached the surface while in 1,24,200 acres zone of salt accumulation exists some where within ten feet depth from the natural surface. Principal salts are sodium sulphate and sodium chloride. With the exception of very clayey strips salts can be leached easily and quickly.

39. In this tract rice, Gram, Wheat, Bajra, Mong, Moth, Gowara, Jowar and Sarson can be grown in normal soil.

II. Rangoi Tohana Tract :—40. It comprises of Blocks L 12, F 12 and northern portions of Blocks L 12 and M 12 and embraces the areas of both Tohana and Fatehabad Tehsil. Total area of the tract is 3,95,341 acres.

41. From the point of view of mechanical composition of the soil the tract can be divided into three classes.

(1) Light loam sandy soil.
(2) Loam.
(3) Clay loam to clayey.

42. Generally the soil met with is of type (2) interspersed with type (1). Type (3) is found on both sides of the abandoned Rangoi Canal and is mostly uncultivated. The majority of the area under type (2) & (1) is cultivated. In the uncultivated land thick vegetation of Karir, Jand, Hins, Wan, Ber, Dub, Dila and Chhimber are found. Bui, Khabal, Bhakra, Dhaman and Lathia are also met with

In the majority of profiles kankar is present. Calcium is the major exchangeable base of these soils, which shows that soils have not yet turned into sodium clays which form Rakkar soil and are very difficult to reclaim. In all 639 profiles representing 3,83,400 acres were taken from this tract. Out of these 3,83,400 acres, 2,05,200 acres are fit for normal cropping directly the water is made available. 11,400 acres are sandy and need consideration if canal irrigation should be extended to this type of land. Reclamation is needed in 1,66,800 acres. While designing the capacity of irrigation channels provision should be made for the extra water supply which will be needed to reclaim the deteriorated soils.

In considerable area only pH values are high which can be reduced by green manuring, if it is high in the first few feet only. If it is high throughout the depth of soil profile, a rice crop followed by a leguminous crop should be taken in the beginning.

43. The depth of water-table varies from 18 to 120 feet from the natural surface. Near Ghaggar the water-table is comparatively high. The Sub soil water in deep profiles is saltish and unsuitable for irrigation purposes.

The quality of soil of this tract appears to be good as in years of good rainfall gram and barley give as high yields as 15-20 maunds per acres and the wheat sown on wells gives an outturn of 20-30 maunds per acre. These soils also do not possess very high exchangeable sodium,as Hissink (8) Gedroiz De Sigmend and Kelley have pointed out that even non-saline soils high in exchangeable sodium are extremely toxic to barley seedling. It has been further confirmed by the investigations of Reftmer, Josefe and Zimmerman and Bower and Wadleigh (3) and Punjab Irrigation Research Institute that exchangeable sodium in amounts varying from 10 to 70 percent of the exchangeable cations, may inhibit the growth of a variety of plants.

III. South of Sirsa and Fatehabad Tract. 44. The areas of Sirsa and Fatehabad tehsil lying in the south and south East of Sirsa town from this tract. It consists of portion of blocks J 12, K 12, L 12, R 12 and S 12. Total area of the tract is 3,75,902 acres. This tract is popularly known as Bagar. Generally, the soil is very light and out of 3,72 600 acres analysed, 1,08,000 acres are excessively sandy. Sand dunes varying in size and height are also scattered. Some of the tibbas are as high as 30 feet and are found to the extent of 10-20% of the total area. In this tract lot of Kankar is found.

45. The Chief vegetations are karir, Jand, Chhimber, Mallah Kikar, Bui and Duchah. The water-table of the area is 90-120 feet. Water-table profile was exposed in Shahpur-Begu. With the exception of certain depths, high salts are present right upto the last foot of the profile in the form of several zones of salt accumulation. Water is unsuitable for drinking purposes. Due to the nature of soil being light, deep water-table and brackish nature of sub soil water large portion of the tract is sown barani. Like sandy soils of Rori Chautala tract, timely rains are capable of producing good yields of crops. The misfortune is that timely rains are of rare occurrence and Kharif crop usually result in poor yields but Rabi crops however give better yields.

46. From the analyses of soil profiles received, 2,01,600 acres i.e. approximately 54% of the total tract is fit for cultivation. 6300 acres require treatment in one form or the other. In this tract also, predominant salts are sodium sulphate and sodium chloride. Other chemical properties of soils of this tract are similar to those of tracts described before.

IV. Barwala Extention Tract. 47. Total area of this tract is 1,47,576 acres situated in Blocks N 12, T 12 and portion of block M 12. It is spread over Hansi and Fatehabad tehsil of Hissar District covering an area of 30 miles long and 8 to 10 miles broad along Jakhal-Hissar Railway line. Most of the area is level and cultivated Barani. Soils of this tract are light loam on the surface but lower down they are loamy and appear to be more compact. They contain kankar also. In years of good rainfall, almost all the area is cultivated Barani. Kikar and Ber are the common trees of this tract. Khabal, Deela and Tandla also grow wild. Sand dunes are also met with. Sand tibbas varying from 15 to 40 feet in height cover approximately 10,000 acres in all. Due to their height and sandy nature, tibbas may be difficult to be cultivated with canal irrigation. While fixing water allowance for this area, 10,000 acres tibbas should be excluded. These dunes can, however, be cultivated Barani for crops like gram and melons in years of sufficient rainfall.

48. According to the number of profiles received for analyses, the total area of the tract works out to 1,92,000 acres out of which only 43,200 acres require reclamation. 38,400 acres are excessively sandy and 10,000 acres of tibbas form a part of this type of soil. Care has to be taken to prescribe deltas for this type of land. Crop rotation requiring large deltas should not be tried because of lesser water-holding capacity of these soils and likelihood of rise of water-table after long period of canal irrigation. As discussed above, this point merits special attention in the development of such types of areas.

Out of 43,200 acres requiring reclamation, 19,200 acres contain high salts somewhere in lower depths of soil profile and can, therefore be reclaimed quickly. These 19,200 acres should find first place in the programme of reclamation, while remaining area can be taken up at a later stage. In the nature of predominant salts and other main characteristics it it not different from other tracts of Hissar district.

49. Sub-soil water-table of this tract is also deep and varies from 80-120 feet. A water-table profile was exposed upto a depth of 120 feet in village Barwala, tehsil and district Hissar. Analyses have shown that high salts exist in the form of several zones of salt accumulation of variable thickness. Sub-soil water is also saltish and unsuitable for irrigation purposes. Drawing of water from such deep wells is also a problem and stood in the way of adopting well irrigation.

V. South West of Hissar Tract. 50. This is the smallest tract covering only 74,803 acres lying south west of Hissar proper. It constitutes Blocks X 12, Y 12 and portions of S 12. It contains no land where salts have appeared at the surface as brought out by the analyses. Only 2,400 acres come under category (1). In these 2400 acres, only high alkalinity exists which can be reduced either by taking one rice crop followed by geen manuring or by Jantar green manuring only.

51. The soil of this tract varies from light loam to sandy loam and is cultivated Barani both in Kharif and Rabi. Kankar varying in size, shape and colour is found in abundance. At places, there are kankar quarries from where it is extracted for road making and kankar lime manufacture.

52. Natural surface vegetation like Bhakhra Chhimber, Khip, Buin and Kondar are common. Karir, Kikar, Jand and Ber are the trees met with. Jawar, Moth, Guara and Mung are sown during kharif and wheat, gram and sarson are grown during rabi.

53. Near the border of Bikaner state, sand tibbas, varying in height from 10 to 15 feet can be seen.

54. Only 11,400 acres are such where salts exist at some depth in the soil profile. 58,200 acres can be directly put under normal crops. For the reclamation of saltish profiles, the technique of land reclamation evolved in Joint Punjab can be applied, as the main salts are sodium chloride and sodium sulphate, but experiments should be carried out to determine the quantity of water required to reclaim each type of deteriorated land. On the basis of the results of these experiments, the capacities of distributaries and minors can be calculated.

55. Depth of water-table in the well varies from 80 to 90 feet. A water-table profile was exposed in village Kirtan which indicated that salts were present from 59th foot right upto 76th foot depth. Sub-soil water being brackish is unsuitable for irrigation.

56. *Karnal District.* Total area of culturable waste land lying in this district is 8.5 lac acres. Two regular soil surveys of this district have been done by the Irrigation Branch. First was the Soil Survey of 1,79,000 acres, lying mostly in Karnal tehsil and some in Kaithal tehsil. Second is the survey of the area likely to be irrigated by Bhakra Project which is a part of the survey under report. On the basis of both these surveys, the lands of the district can be classified into three general types.

57. (i) This type of land is deteriorated to a great extent. Both the salt content and pH values are very high through out the soil profile Clay content is also high and water-table is more than 10 feet. In this soil, sodium has entered the exchange complex of the soil. On account of the presence of sodium carbonate, the soil structure, which is the key to all fertility, has been destroyed very considerably. The second problem which confronts these areas is the presence of hard pan at some depth from the surface. Reclamation of this land will need lot of water and time. The results of experiments, being carried out on such lands,will prove helpful in formulating reclamation schemes for this class of land.

58. ii) Lands where deterioration has not extended very far. High salts are present at some depth in the soil profile or at the surface. In certain areas there may be slight rise in the alkalinity. With the advent of canal irrigation, reclamation can be taken up as it will be comparatively much easier than in type (i).

59. (iii) It is the type of land where water-logging or high water-table exists. In the upper reaches of the Western Jumna Canal Main Line, there is no problem of salinity or alkalinity but in the lower reaches the problem of water-logging exists in conjunction with high salts or high pH values or both.

60 Reclamation of upper reaches can be done by providing drains and taking such crops in the beginning which require large deltas to mature.

Reclamation of lower reaches is a bit more difficult but with the availability of more data about experiments in such type of land (Indri Reclamation Farm is an example) it will be possible to ameliorate these soils also.

61. The main difficulty with the soils of this district is that they contain sodium carbonate and sodium bicarbonate as the principal salts which make the problem of reclamation more complex. The drainage of this district is also very poor. The primary influence of adequate drainage on soil structure lies in the removal of excess water, with a corresponding increase in the air capacity. Due to the increase in aeration, there is more intense bacterial activity, promotion of oxidation processes and a greater root development. The net result is the better granulation in soil and, hence, greater fertility will accrue.

62. For the study of deteriorated lands infested with sodium carbonate and sodium bicarbonate and to evolve a modified technique of reclamation suiting new conditions, sufficient experimental work is required which needs time, patience and funds. There is sufficient time till Bhakra Project will be completed and funds should be reserved for this important work. The required talent for this work is already available in the Irrigation Research Institute.

63. To prevent the rise of water-table and consequent rise of salts, when canal irrigation is introduced, it is imperative that the minimum quantities of water required for maturing crops is investigated and channels are designed accordingly. Crop planning should also be such that least damage is caused.

VI. West of Pehowa Tract : 64. In this district, there is only one tract, named west of Pehowa tract. This tract comprises culturable waste lands of Kaithal and Thanesar tehsils of Karnal district and southern most portion of Ambala district. It is spread over Blocks P 11, Q 11, Z 11, Z 12 and portions of G 11 and G 12. This tract is bounded by Ghaggar river in the North, Karnal district boundary in the West, Irrigation boundary of Sirsa Branch in the South and a line drawn from the point where Pehowa-Ambala Kacha road leaves Karnal district to village Thol and the Sirsa branch in the East.

Many Kharif torrents pass through this tract which have influenced the soil and have helped in the formation of different types of soils. They also serve as natural drainage but most of the Nallahs have no outlet and are not big enough to drain away all the run-off water. Rainfall of the district is approximately 23 inches on the average and a large portion of this tract gets submerged during monsoon monts when most of the rainfall viz. 18 inches is received. This delays sowing of Rabi crops which results in lower yields. Broadly speaking, the tract can be subdivided into three zones. One zone is the rich, fertile land in Bet areas of Markanda, Umla, Jodha etc. Generally the soil is loam to silty loam interspersed with clay-loam strips. 80% of this zone is cultivated and good yields are obtained. In profiles, kankar is also encountered. Second zone is along Saraswati Nadi. Soil is hard, impervious, stiff clay and cracked at the surface. It is low lying area which gets submerged under water during monsoon and major portion is covered with thick jungle of

Dhak. Both the salt content and pH values of this area are very high. The third zone comprises of an area which is almost flat and level but is lying uncultivated. A portion of the area is in an advanced stage of deterioration, where clay content is very high. On account of inadequate drainage, cultivation is obstructed during rainy season. Soil crust of the district is generally more than 10 feet thick.

65. Total area of this tract, surveyed during the course of Bhakra soil survey, is 4,82,400 acres out of which 2,08,800 acres i.e. approximately 43% area is in different stages of deterioration and in 1,38,600 acres, it has raised its ugly head even at the surface. In this tract, lot of kankar is met with.

66. Unlike Hissar soils, sodium has entered the base exchange complex which is the major cause ef low yields. As already stated, considerable number of profiles are in an advanced stage of deterioration due to the conversion of the soil into sodium clays. Reclamation of these soils will require longer time and also more effort and expenditure.

67. Water-table in the district varies from 0'' to 37 feet. Considerable area is already water-logged. One of these is the Bahauli area which is approximately 20,000 acres. In this tract the water supply in the wells is inadequate and wells are not capable of being worked continuously. Sub-soil water is suitable for irrigation purposes, but at some places it is saline. Water-table profiles were exposed in each type of zone which, on examination in the laboratory, have indicated that salts exist much below the ten feet depth.

68. The problem in this tract is three-fold namely, leaching of salts, lowering of alkalinity and improving the tilth of the soil. High clay content and kankar percentage will contribute towards slow progress of reclamation. 2,73,600 acres belonging to this tract are fit for normal cultivation but to improve the yields, some milder methods of reclamation will have to be adopted to obtain better tilth required for the aeration of plant roots. In other words injurious effect of high clay content has to be contracted and over-come. A correct appreciation of the mechanism of plant nutrition in relation to the different types of soils found in these conditions is of the highest importance in aggriculture and food production. Some funda-

mental-cum-practical work is necessitated in this direction before we can confidently recommend suitable reclamation measures.

69. Almost the entire area of the tract is capable of giving good yields of crops when injurious effects of salts, alkalinity and high clay content are eliminated.

Ludhiana District. 70. In this district, all the three types of cultivation are found viz. Barani, well irrigation and canal irrigation. Almost cent per cent area of this district is cultivated. Therefore, big jungles or vegetation of permanent nature is absent. It is the most intensively cultivated district of Punjab state. The pressure of cultivation on land of this district is so heavy that at places mixture of four to five crops is sown in the same field. The land in the district is rarely left fallow with the result that it appears to be almost exhausted because for good yields, the application of farm yard or inorganic manure is a normal routine. The holdings are small and scattered. Village Shamlats are very small. Trees like kikar and Ber are grown for providing thorny hedges round the holding. Among ground vegetation Kabbal, Swank, Untchara, Panwar, Bhakra, Kahi and Moth are found.

71 From the mechanical analysis results, the soils of the district are indicated to vary between loam and sandy. Depending on their texture they have been given some local names like Dakar, Raunsli and Bhudi. Loam is called Dakar. Light loam is termed as Raunsli. Soils exist mixed and no clear demarcation of each type can be done. In between, Bhudi is also encountered.

72. To develope each type of land, the grid system of one profile in 600 acres cannot correctly represent the actual location of each type of land. The variations are so great that more intensive soil survey of this district is absolutely essential in order to obtain an exact and correct picture of the area. If this is done, it will fecilitate the fixation of water-allowance for each channel so that maximum use of the water is made without disturbing the soil fertility and without involving a risk of water-logging after some time.

73. Soil crust varies between 2-8 feet in loamy and light loam areas. In sandy areas, the analyses have brought out that generally the clay content is less than 6% througout the soil profile. However, in some portions where clay percentage is noticeable at depth in the soil profile, kankar is present. Unlike Hissar

soils, the rainfall in the district is approximately 24·4" on an average and the humus and organic matter added to the soil through the application of farm yard manure is not burnt by the sun. At present, due to well irrigation, bullocks and milch cattle are present, in numbers sufficient to produce required quantity of farm yard manure. With the introduction of canal irrigation, number of milch cattle will have to be increased to ensure sufficient supply of the manure as bullocks will go out of use. Inorganic fertilizers, like sulphate of ammonia, are also useful for crops but for every 100 lbs. of ammonium sulphate used, 75-150 lbs. of calcium carbonate would be lost from the soil. When the reserve of calcium carbonate is exhausted, the loss falls on exchangeable calcium. Calcium carbonate itself is very useful for the soil because it brings soils into a better physical tilth and also protects both potassium and magnesuim against loss by leaching. Further work is necessary before we can formulate our final opinion on the correct use of artificial fertilizers. Detailed analyses of Ludhiana soils have shown that they contain little quantity of calcium carbonate. It would, therefore, be in the interest of maintining soil fertility that organic manures are used instead of ammonium sulphate. Farm yard and other organic manures maintain an adequate supply of iron and other trace elements needed by the crop in an available form in alkaline soils which is the basic characteristic of Punjab soils.

74. In barani areas, there are no bunds. After the introduction of canal irrigation, run off will greatly decrease due to the construction of field bunds. Moreover, canal irrigation will be profuse and thus there will be a real danger of water-logging. Steps should be taken to prevent such happening by controlling the deltas and by providing surface drainage to counteract heavy rainfall.

75. Due to small and scattered holdings framing of warabandis will be a headache. To avoid this difficulty, and also to eliminate waste of water in 'Nikals', rectangulation and consolidation of holdings should be underkaten immediately.

75. In this district there are two tracts which are discussed below : –

VII. Khanna Samrala Tract. 77. In this tract are included

Blocks M 10, N 10, Q 10, and portions of U 10 and V 10. Total area is 1,68,632 acres, situated in Khanna and Samrala tehsil of Ludhiana district and a portion of Ambala district. It is bounded by Sirhind Canal in the North, Ludhiana district boundary in the South, Bhakra Main Line in the East and Patiala Branch in the West.

78. The depth of soil curst varies from 0′-8′. Excessively sandy soils having no or little soil crust are known as Bhudi. Kankar is found in many profiles. Bhudi type of land is most suitable for ground-nut cultivation which is already done, but yields are not so good. In order to obtain good yields, deep green manuring should precede the crop. At the time of sowing i e. in the beginning of June, light canal irrigation may be done. No irrigation should be done till the end of September or beginning of October. If no rains are received during these months, one irrigation may be given to mature the crop. With the introduction of green manuring in rotation for this type of land, there are possibilities of obaining Rabi crops.

79. The water-table of the area varies from 6 to 35 feet and the subsoil water is sweet.

80. Out of 1,92,600 acres surveyed, only 27.000 acres have deteriorated and need reclamation. Rest of the area i. e 16,500 acres, are fit for taking normal crops but. development of normal area also needs careful crop planning and effective management as the soils being generally not heavy need only light irrigation. For the restoration of plant nutrition green manuring, preferably underground. may have to be frequently resorted to. But the depth at which the under ground green manuring is to be resorted to, needs proper investigation in relation to the soil conditions as discussed in the previous paragraphs

III. Ludhiana Jagraon Tract. 81. Under this tract come Blocks F 10, portions of E 10, M 10 and U 10. It is bounded by river Sutlej in the North, Moga-Kot Kapura Road in the West, Patiala Branch in the East and a line drawn near Malerkotla in the South. Total area surveyed of this tract is 1,75,800 acres out of which 1,51,800 acres can be put under normal cropping. Only 24,000 acres are such which need reclamation or some kind of treatment to reduce high alkalinity. Generally, the soil is of light type.

Detailed analysis of profile from Burki-kalan village in Tehsil Ludhiana was carried out. The analyses indicated that this soil also contains little calcium carbonate. Inspite of low salts and low pH values degree of alkalisation is sufficiently high which indicates that fertility index of soil is low. Results are given in Table 4. Though there may not be big reclamation problem in this tract but restoration of normal fertility requires attention and methods have to be applied to restore it.

82. Water-table of this tract varies as in Khanna Samrala tract. Careful management of canal irrigation water is needed. Water is fit for cultivation.

83. In areas where zone of accumulation of salts exists in the soil profile, the predominant salts are sodium sulphate and sodium chloride. Reclamation of the land will be quick and easy due to the light type of soils.

IX. Ferozepur District. 84. In this district, there is only one tract named Grey Canal tract, the area of which is approximately 4,25,000 acres. It covers blocks B 10, C 13, D 10, J 10, K 10, Q 10, R 10 and portion of E 10. It is bounded by river Sutlej in the North. Sutlej navigation canal in the South and Kot-Kapura-Moha-Jalalabad Road in the East. The entire tract is served by a net-work of inundation canals known as grey canals after which the tract has been named. The canals are non-perennial and supply irregular, supplies of water having incomplete irrigation record. Rainfall is approximately equal to that of Hissar district i. e. 14 inches. This is the worst of all the tracts.

85. It is subject to floods from river Sutlej and a strip of about 3 to 7 miles all along the river remains under water during the monsoon. Due to occasional floods, soil near the river consists of different layers of sand and clay which is deposited by the flood water. Water-table in this strip of land varies from 0 to 4 feet during winter. Kankar is absent. Here the problem is two-fold. Not only the soil is impregnated with injurious salts as indicated from analyses but the water-logging also demands immediate solution.

86. Soil away from this strip is even and in general light. It can be called light loam.' Kankar is also met with in the form of belt. In this area, both high salts and high pH values are found

either separately or jointly. Majority of the land can be considered fit for cultivation. Natural vegetation of Grey Canal tracts is Dab, Khai, Sarkanda and Pohli, the last being very conspicuous both in cultivated and uncultivated land. The eradication of Pohli is one of the real problems to be tackled. On wells shisham, mangoes, Jaman and Mulberry are cultivated. Among trees Ber, Jal, Kikar are also noticeable.

87. Out of 4,66,800 acres of the tract surveyed, 1,89,600 acres need treatment and the rest can be directly brought under the plough. Deteriorated soil should be first reclaimed and then allotted for cultivation. In the majority of deteriorated profiles salts have already appeared at the surface. It will be more economical to first reclaim those areas where salts exist not at the surface but at some depth within the soil. Technique of land reclamation evolved in West Punjab can be applied to this tract with success as major salts are sulphates and chlorides of sodium.

88. The areas which are vulnerable to floods have the fertility invariably upset because of ravages of the flood water. The over-all picture of the tract is not very bright but given the will to improve the land it can range among normal lands of the province. Surface drainage also needs judicious and careful remedies.

89. Detailed analyses of a profile taken in village Bura Gujjar of tehsil Muktsar are shown in Table 4. Water from subsoil is sweet and suitable for irrigation purposes.

X. Jullundur District 90. In this district is situated one tract called Bist Doab Tract. It consists of Blocks B. D. I. to B.D. 52. Actual area of the tract proposed to be irrigated by Nangal Bhakra project is not known. From the number of soil profiles taken on the grid system of one profile in 600 acres, it works out to 4,11,00 acres The soils of the tract are loamy to silty and are capable of giving normal yields. Almost all the tract is cultivated Barani or by means of wells. The intensity of cropping in this district also is fairly high. Every type of crop is taken in this district. Kankar is also present in many profiles. Annual rainfall is 25.3 inches

91. Out of 4,11,000 acres, 3,49,200 acres of land is good in all respects and is fit for the introduction of canal irrigation. Deterioration is indicated only in 51,000 acres while the soil of

10,800 acres is excessively sandy. Reclamation of this tract will not be difficult as the pH values are not very high and there is preponderance of exchangeable calcium which indicates that deterioration is yet in early stages. Detailed analyses were carried out of two profiles results of which are given in Table 3. In village Tahang, tehsil Phillaur, kankar is present in very high percentage. It is as high as 28% in the first foot and 21% in the second foot. In areas where kankar is found in such high quantities kankar lime can be profitably extracted for commercial purposes if not already quarried.

92. Eight water-table profiles were exposed in different blocks. The water-table varies from 11 feet to 34 feet. Water is is fit for irrigation purposes. The profile dug in village Nakodar shows the existence of high salts right upto 27 feet depth beginning from the surface. Total depth of the profile was 32 feet.

93. It is, therefore, possible that if water-table begins to rise abnormally on the introduction of canal irrigation, there are chances of tremendous amount of salts coming up with it. Hence the necessity of controlled irrigation after careful planning which can be done only on the basis of results of experiments about water requirements.

94. For more than last half a century water-table of the Bist Doab has been going down and many wells had to be abandoned. Various departments had been given the problem of investigating the causes of lowering of water-table. Each of the departments advanced its own reasons, but on one point all were unanimous that indiscrimate deforestation in the Shiwalik Hills was the major cause. Due to heavy deforestation the run-off rain water directly reached there without much seepage on the way. The seepage of rain water and choe water enables the water-table to maintain its level. In the absence of much needed seepage, costent lift irrigation through wells resulted in lowering of water-table. With the advent of canal irrigation, the subsoil water table will recover its original level. Thus more water will be available for well irrigation where canal water will not be available.

95. However, in the canal irrigated area some rise of water-table may be tolerated but after a certain stage the continuous rise in water-table may create the problem of water-logging which should

be avoided. Thus there is much more necessity of the planning in fixing water allowances and deltas. It should be done before actual irrigation from canal starts.

SUMMARY

Area surveyed is scattered over ten distinct tracts situated in the districts of Hissar. Karnal, Ambala, Ludhiana, Ferozepore, and Jullundur. In all, the area comes to 33,04,200 acres from which 5507 profiles were taken on a grid of one profile in 600 acres. Out of this area, 20,10,600 acres i.e. approximately 61% land is fit for cultivation on the introduction of canal irrigation. 30% or 9,93,600 acres are in different stages of deterioration and need treatment. The kind of treatment required depends on the existence and extent of one or more factors which are responsible for its deterioration. 3,00,000 acres or approximately 9% area is excessively sandy and provides food for the thought whether canal irrigation should be introduced in this type of land, whether it will respond to canal irrigation and what are the expected after effects of such irrigation. The second problem which merits immediate attention is to investigate how far the winds blowing from Rajasthan State are contributing toward the formation of sandy tract in Hissar District. Forest belts may be necessary to check the on-slaught of these winds. Hence, a proper survey will have to be carried out in collaboration with Forest Department.

The soil of each district presents its own peculiar problems, brief accounts of which are given below :—

A. Hissar District.

Problems. 1. As the soils are generally light, even in good soil the plant food is liable to be washed down due to canal irrigation which is generally much more profuse than well irrigation or barani cultivation.

2. Reclamation of deteriorated lands where salts are present either at surface or at some depth below.

3. Amelioration of land having high alkalinity.

4. Advisibility of introducing canal irrigation in excessively sandy areas.

5. Conservation of irrigation water.

6. Conservation of soil fertility.

7. Problem of rise of water-table.

Remedies suggested. 1. Large tracts have covering of sand or sandy soil. Normal water allowance may do harm than good. Deltas for each type of crop suiting soil and climatic conditions of the area should therefore be fixed. This work requires experimentation both on laboratory and field scales for which there is ample time yet, provided funds are sanctioned.

2. For the reclamation of salt infested land extra quantity of water will be needed in the beginning for the cultivation of rice and leguminous crops. The location and extent of area having been known and the amount of the water required for reclamation calculated; it should not be difficult to fix the capacities of irrigation channels. Water allowance for these tracts should be fixed accordingly.

An present with one cusec of water 45 acres of land are taken up for reclamation, but so for no experiments have been carried out to see how much water and time will be sufficient to leach down certain amount of salts from a certain depth to below pellicular zone in a particular type of land. If these experiments are done, it is expected that further economy in the quantity of water for the reclamation of a certain tract may be effected.

These experiments will also help in predicting the time required for the reclamation of each field more accurately, which in the long run will economise the use of canal water.

3. For lands having high alkalinity throughout the depth of soil profile, one rice crop followed by a leguminous crop in the beginning may improve the land. If, however, pH values are high in the first two or three feet only, green manuring, preferably under ground, will depress it to prescribed limits.

4. In excessively sandy area canal irrigation may not be successful. It may prove profitable to leave them barani. Something definite can be said after experimental evidence is available for Hissar soils. If the Government agrees, this work can be taken up.

5. Hissar soils give exceedingly good crops both Kharif and Rabi if rains are received at appropriate time. Thorough study of existing irrigation practice and rainfall should be made. Experiments should be carried out to determine crop rotation pertaining

to particular type of soil, best sowing time and time of subsequent irrigations for Kharif as well as Rabi crop along with conservation of soil fertility and maximum yield. Frequency curves for C.C.A. on each distributary can be prepared and regulation done accordingly.

6. In Hissar soils application of Farm Yard manure does not suit as organic matter gets burnt due to excessive heat and constitutes only a surface application.

Green manuring at a particular depth from the surface may prove helpful. A detailed study of the suitability of different relations to the variation in soil conditions and crop rotations is necessary before final advice on this matter can be given. Its effect on water-holding capacity, inorganic soil compounds, supply of soil colloids and micro-organic activity should also be studied.

These experiments will provide further information about economy in the use of canal water and better yield.

7. Due to light nature of soil, there will be lot of seepage through water-courses and fields which will eventually raise the water-table and water logging will bring in its trail, the problem of rise of salts. Following measures may be adopted simultaneously to fore-stall the danger of rise of water-table.

(*i*) Irrigation should be controlled and fixed deltas should be allowed for each kind of crop so that seepage is minimum.

(*ii*) Fields should be made as small as possible.

(*iii*) Horizontal concrete porous galleries may be provided at a depth just below pellicular zone. Frequency intensity of these galleries and the latest date by which they should be installed requires detailed study which should be immediately taken up if the suggestion finds the approval of authorities.

(*iv*) Torsion survey will provide useful information on this point.

B. Karnal District

Problems. 1. High water-table areas.

2. Reclamation of soils containing high sodium carbonate and sodium bicarbonate, high clay content and high alkalinity.

3. To investigate the formation and consequent reclamation of hard pan areas.

4. Danger of water-logging.
5. To improve the tilth of the soil.

Remedies. 1. High water-table areas exist along the Western Jumna Canal Main line. These are of two types. One containing high salts and other where only water logging exists.

For reclaiming type first having salts along with water-logging, drains should be provided; and if drained water is good, it may be used for reclaiming the soil. The second type may be provided with drains and reclamation started. Indri Reclamation Farm will provide information about the first type and for type second, tubewells are being bored for lifting extra water and putting it into the Main Line for use in the district of Rohtak. During Kharif, when water supply in the canal will be sufficient, the tube-well water can be and should be used for the reclamation of the first type.

(2) & (3). Reclamation of Karnal soils is a complex problem due to the presence of sodium corbonate and sodium bicarbonate as principal salts, existence of high clay content and hard pan at certain depths and occurrence of kankar in high percentage. Reclamation technique evolved in the Joint Punjab needs certain modifications for which experiments both in the Institute and at Experimental Farm, Nissang are being carried out.

4. Planning of crops and their deltas is a necessity which should be worked out before canal irrigation is actually introduced. Actual experiments should be done before they can be correctly prescribed.

5. Investigations will have to be undertaken to devise methods to improve the tilth of Karnal soils which are generally damaged. Green manuring is one of the methods to counteract the harmful effect of high clay and consequent compactness of the soil.

Ludhiana District.

Problems. 1. Likelihood of water-logging on the introduction of canal irrigation.

2. How to avoid waste of water due to small and scattered holdings.

3. To restore soil fertility.

4. To increase yields of crops in sandy area.

Remedies. 1. Surface drainage should be provided to deal with run-off water due to heavy rainfall. Canal irrigation should be under strict supervision and control so that movement of moisture is restricted to the pellicular zone. A well survey of the district should be done now and again after the introduction of canal irrigation to determine the extent and time required for the appearance of water-logging.

2. Consolidation of holdings, rectangulation and Killabandi of the entire area is suggested. There should be a legislation that no further sub division will be permitted. After consolidation, framing of warabandis will also be smooth which otherwise will be very difficult and complex in fragmented and scattered holdings.

3. Green manuring and application of farm yard manure may be followed as a rule because Ludhiana soils appear to have reached fatigued stage. On the introduction of canal irrigation, milch cattle should be increased so as to replace bullocks now used for well irrigation. Well survey suggested above and data collected in that connection will prove useful to find out the real cause of deficiency in soil fertility.

4. This can be done by judicious use of irrigation water at appropriate times and use of green manuring with Jantar, Gowara or San.

Nutritive value of present crops and their effect on the health of local people should be investigated now and also after the advent of carefully managed canal irrigation as recommended above. It will be helpful in putting the agricultural practice of the district on more sounder basis.

In order to develop the tract on profitable lines, this district should be surveyed more intensively as one profile from 600 acres cannot enable to demarcate distinctly three main types of soils of the district viz. Dakar, Rounsli and Bhudi which are found to be greatly intermixed in each 600 acre unit.

D. Ferozepore District.

Problems. (*i*) Drainage.

(*ii*) Reclamation of deteriorated soils.

Remedies.

(*i*) Same as proposed for other districts.

(*ii*) For the reclamation of deteriorated soils, extra water will have to be provided while designing the capacities of irrigation channels. Having located the plague spots, provision for this can be made after determining the time and quantity of water required to wash down the high salts or to depress high pH values. Quantity of water and time needed depends on the amount of salt and the depth at which it exists.

To obtain this information about each broad type of deteriorated soil, experiment both in the laboratory and in the field shall have to be carried out. These experiments are also expected to further economise the quantity of water supply needed for reclamation purposes.

In high water-table areas drainage will have to be provided simultaneously with reclamation operation if some tangible results are to be obtained.

E. Jullundur District.

Problems :—(*i*) Abnormal rise of water-table on the introduction of canal irrigation.

(*ii*) Control of choes during monsoon.

(*iii*) Effect of canal irrigation on agricultural practices of the district.

(*iv*) Reclamation of deteriorated lands.

Remedies.

(*i*) Controlled irrigation and careful planning should be adopted Having known the quantity of water required to mature crops in Jullundur soils, making allowance for heavy rainfall, it is possible to calculate the probable water allowance. Water allowances should be restricted so as to reduce the rise of water-table to aminimum.

(*ii*) The reclamation of Choes needs immediate investigation. After proper engineering survey of the choes, model experiments can be laid down to study the best type of training works or what types of bunds viz. Check bunds, ring bunds, or any other measures are required to control the choes. It is very gratifying to note that the Forest Department is actively persuing the policy of afforestation in these areas.

(*iii*) In Bist Doab tract, canal irrigation will be introduced for the first time Experimental and demonstration farms should be established to study the effects of canal irrigation by growing crops on the deltas which will be allowed under canal irrigation. These farms can also help in demonstrating the practical advantages and dis-advantages to the zamindars.

(*iv*) Reclamation of this tract will not be difficult as indicated by the analyses of large number of profiles from this district.

General Suggestions. The presence of alkalies or undesirably high concentration of salts is very common in soils of the arid and semi arid regions of the world. The salts of Sodium occur by far the most abundantly. Hence, the term 'alkali soils'. The property of many alkali soils which obviously may restrict the growth of plants is the excessive concentration of soluble salts and the resulting high osmotic pressure of the soil solution. The effect on plants produced by different salts vary greatly, that is, white alkali (Sodium Sulphate and or Sodium Chloride) is much milder in its effect on plants than is 'Black alkali' (caused by the presence of sodium carbonate).

It is an established fact that Punjab soils contain salts both white and black alkali. There is also no gainsaying the fact that before a particular land goes out of cultivation or there is some marked decrease in the yields of crops, a gradual and unobserved fall in yields takes place. It takes place on account of action of Sodium salt on the exchangeable base complex with the result that poor soil structure develops.

No correctives are applied till visible signs of deterioration raise their ugly head. These signs manifest themselves when the soil reaches a stage which only costly reclamation can improve. Moreover, regular records of yields of crops which could be used in giving indication of gradual decline in the soil fertility are also not kept. It is true that lower yields can be also due to some other reasons and factors but a careful record of yields examined with rainfall and other climatic and meteorological factors can give a fair idea of the progress of deterioration.

It is always easier and quicker to arrest the decline in the quality of soil if it comes to the notice before it advances, as it is of less intensity and extent at that time. When a piece of land totally goes out of cultivation, it is a loss both to the farmer and the Government.

Due to lack of proper education and knowledge among the zamindars, he remains an idle spectre even if he comes to know about the injuries which are in progress. Therefore till our village brethern become properly educated, it rests with the Government to get the scientific examination of soils done and prevent land deterioration. Periodical checks in the form of soil surveys should thus form a part of regular fertility control of land on which depends the revenue derived from canal irrigation.

If such periodical surveys are done before initiating settlement operation in each district, results of these surveys will also prove helpful in the actual settlement. At that time it would be much easier to adopt corrective measures which may not necessarily involve loss of crops which generally happens in the first year of full-scale reclamation.

(*ii*) As a result of Bhakra soil survey we know that approximately 10 lac acres of land need treatment before they can be put under normal rotation of crops.

This survey convered only six districts of Hissar, Karnal, Ambala, Ludhiana, Ferozepore and Jullundur. It will be only correct to presume that in atleast other four districts of the State viz. Amritsar, Gurdaspur, Rohtak and Gurgaon, deterioration must be existing in one form or the other.

It is also supported by the thur Girdawari figures of Kharif, 1951, carried out by the Civil Department through their Patwaris in the above four districts. According to the Girdawari 36,071 acres of thur land existed in Kharif, 1951, while in Kharif, 1950, total figures for these four districts were 34,937 acres. It may be mentioned that the number of villages under operations of this girdawari were not many. Number of villages is given below :-

	District	*No. of villages*
1.	Amritsar	375
2.	Gurgaon	167
3.	Gurdaspur	44
4.	Rohtak	8

The thur Girdawari figures will certainly be very disquieting if the Girdawari is extended to all the villages of the four districts referred to above. These figures indicate only the actual damaged area of those fields which give a less than four annas crop. Deterio ration not visible to the naked eye must have been going on in much larger area.

It is therefore necessary that soil survey of these districts is also carried out to know the exact extent of deterioration and if need be corrective and reclamation measures may be taken.

Practical utilization of results :-

1. Exact information about bad and good area is obtained.

2. Quantity of water required to be given on each outlet can be worked out i.e. quantity of water (include that needed for reclamation) required to be run initially and ultimately in each channel.

3. Adoption of crop planning for good lands.

4. Designing of reclamation project and suggesting methods of reclamation for bad areas

5. Recommending specific and new rotations for certain types of lands.

6. Fixation of priorities for irrigation, keeping the soil characteristics and level etc. of land in view.

7. Demarcation of areas requiring surface drainage etc. to avoid water-logging and measures to prevent rise of water-table in areas prone to this tendency.

8. Indicating cottage and other industries which are likely to be established as a result of crop planning and adoption of those crop rotations.

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Methods of dissemination of important information to Zamindars.

Zamindars have to be educated about the appropriate crops, best sowing time, conservation of fertility and methods and technique of reclaiming deteriorated soils. This can be done as follows :

In general, human nature does not adopt new things till one is convinced about their usefulness. The Punjab farmer is a diehard in that respect. He will not be prepared to adopt new techniques and methods of rotations on his land till he is convinced about their effectiveness and use. Therefore, experimental and demonstration farms should be opened in each type of land met within each of the ten tracts discussed in the fore-going pages. At these farms, following experiments should be tried on field scale in addition to investigations on laboratory scales These farms can work on tube-wells if canal water is not available in the vicinity.

(i) Investigation regarding quantities of water and time needed for the reclamation of different types of deteriorated soils so that programme of reclamation may be properly planned and framed to make the best use of surplus water which may be available in the beginning of irrigation project.

(ii) Methods of conservation of canal water.

(iii) To investigate the question of warabandi suiting local soil conditions.

(iv) Investigation regarding the rise of water-table on the introduction of canal irrigation due to seepagel osses in minors, water-courses and fields and to find out measures to check it with reference to rainfall of the tract.

(v) Design of capacities of distributaries with reference to crops suiting the area.

(vi) To determine the best sowing time of crop and irrigation with regard to maintenance of soil fertility and maximum yields.

(vii) Conservation of soil fertility.

(viii) To investigate possibilities and methods of deep or underground green manuring with particular reference to its economies.

Other methods of imparting knowledge to zamindars are,

(b) Through leaflets on each point of interest.

(c) By means of propaganda through Community Project Officers where such project is in progress.

(d) Through popular lectures in villages by persons carrying out the experiments indicated above.

(e) With the help of cine films prepared about land deterioration, its reclamation and other experiments and arranging films shows through Public Relations Department.

(f) By means of interesting articles in local newspapers, journals and magazines.

Legislations.

1. Enactment of legislation embodying important points about crop rotations to be followed.

2 Law laying down conditions for new allotments and leases on the basis of experimental data and results.

3. Legislation to restrict fragmentation and sub-divisions of holdings.

4. Amendments in canal act regarding Land Reclamation, drainage and other measures which may be necessary.

TABLE 1

Showing classification of land surveyed in different tracts of Bhakra Soil Survey.

Serial No.	Name of tract	Total area in the tract.	Area surveyed as calculated from profiles.	Land good in all respects.		Area excessively sandy, salt content and pH values normal.		Area having high salts with or without high pH value at some depth of profile.		Area having high salts and or high pH value near the surface.	
				Area	%	Area	%	Area	%	Area	%
1.	Rori Chautala Tract.	6,83,346	5,55,000	2,87,400	51·78	61,200	11·02	1,24,200	22·37	82 200	14·81
2.	Rangoi Tohana Tract.	3,95,341	3,83,400	2,05,200	53·52	11,400	2·97	72,600	18·93	94,200	24·56
3.	South of Fatehabad & Sirsa Tract.	3,75,902	3,72,600	2,01,600	54·10	1,08,000	28·98	45,000	12·07	18,000	4·83
4.	Barwala Extension Tract.	1,47,576	1,92,600	1,11,000	57·63	38,400	19·93	19,200	9·91	24,000	12 46
5.	South West of Hissar Tract.	74,803	72,000	36,000	50·83	21,600	30·00	11,490	15·83	2,400	3 33
6.	West of Pehowa Tract.	4,51,518	4,82,400	2,71,800	56·34	1,800	0·37	70,200	14·55	1,38,600	28·73
7.	Khanna Samrala Tract.	1,68,632	1,92,600	1,65,000	85·66	600	0·31	14,400	7 47	12,600	6·54
8.	Ludhiana Jagraon Tract.	Not known	1,75,800	1,38,000	78·49	13,800	7·84	9,600	5·46	14,400	8·19
9.	Grey Canal Tract.	4,25,000	4,66,800	2,44,800	52·44	32,400	6·94	62,400	13·36	1,27,200	27 24
10.	Bist Doab Tract.	Not known	4,11,000	3,49,200	84·96	10,800	2·62	32,400	7 88	18,600	4·52
	Total		33,04,200	20,10,600	60·85%	3,00,000	9 08%	4,61,400	13 96%	5,32,200	16·11

TABLE No. 2

Showing Results of Analyses of a few typical Profiles.

Lab. Regd. No.	Depth.	T.S %	pH	Clay%	Kankar%	Remarks.
V. Mewad Khurd Tehsil Fatehabad, District Hissar Block F.12. Sheet 2 Profile 6						
B. 5704	1'	·83	9·6	20·0	Nil	
5	2'	·78	9·9	20·3	Nil	
6	3'	1·99	9·9	23·1	Nil	
7	4'	1 23	10·0	24.4	Nil	
8	5'	1·34	10·0	23·4	Nil	
9	6'	1·45	10·1	26·1	Nil	
10	7'	1·28	10·1	26·1	Nil	
11	8'	·83	9·9	18·4	Nil	
12	9'	·68	9·9	17·3	Nil	
13	10'	·86	9·0	19·1	3·0	
V. Dhan Ayalki Tehsil Fatehabad District Hissar Block E12 Sheet 18 Profile 12						
B 9035	1'	1·55	8·1	5·0	Nil	
36	2'	·055	8·5	3·5	Nil	
37	3'	1·12	8·2	4·2	Nil	
38	4'	·56	8 4	3·6	Nil	
39	5'	·12	8·4	4 9	Nil	
40	6'	2·30	8·5	5·6	Nil	
41	7'	1·12	8·3	8·4	Nil	
42	8'	1·23	8·2	10·8	Nil	
43	9'	2·47	8·1	11·6	Nil	
44	10'	1·05	8·0	13·7	Nil	
V. Rupewal District Hissar Block F12, Sheet 6 Profile No. 10						
B. 7089	1'	·01	9·2	9 1	Nil	
90	2'	·04	9·2	12·3	Nil	
91	3'	·08	9·1	10·1	Nil	
92	4'	·01	9 4	9·6	Nil	
93	5'	·02	9 4	10 8	Nil	
94	6'	·04	9·5	9·2	Nil	
95	7'	·02	9·6	7 8	Nil	
96	8'	·01	9·6	9·3	Nil	
97	9'	·03	9 6	7·8	37·0	
98	10'	·03	9·6	9·5	Nil	
V. Mund Hatian District Hissar Block F 12 Sheet 1 Profile No. 10						
B. 8995	1'	·02	8·4	15·7	Nil	
96	2'	·01	8·3	12·3	Nil	
97	3'	·02	8 3	11·5	Nil	
98	4'	·04	8·3	12·3	Nil	
99	5'	·03	8·3	10 3	5·7	
9000	6'	·04	8 2	9·2	Nil	
1	7'	·02	8·3	12 0	4·9	
2	8'	·03	8·2	10 0	Nil	
3	9'	·01	8 4	6·4	Nil	
4	10'	·01	8·3	4·1	Nil	

TABLE 3

Showing analyses of soils from different tracts of Bhakra Soil Survey.

Lab. Regd. No.	Depth of profile	pH value	T.S. %	Total carbonate CaCo 3 %	Exchageable		Humus mg	Nitrogen mg	ankar %	Clay %
					Na—k m. e.	Ca m.e.				
1	2	3	4	5	6	7	8	9	10	11
V. Nasirwala Tehsil Zira Distt. Ferozepur Block E 10 Sheet 12 profile No. 2										
47855	1 foot	8 67	·05	·25	1·1	5·9	414·0	84	Nil	6·08
56	2 feet	8·8	·058	25	1·2	5·8	480·0	56	,,	8·93
57	3 ,,	8 51	·071	·25	1·2	6 5	100·0	49	,,	9·39
58	4 ,,	8·60	·07	1·0	1·3	6·9			,,	9·49
59	5 ,,	8 60	07	1·25	·9	6·6			,,	10·73
60	6 ,,	8·57	·08	1 65	1·1	7·7			,,	7·88
V. Mirzapur Tehsil & Distt. Hissar Block T 12 Sheet No. 2 Profile No. 11										
2910	1 foot	9·2	224	7.5	1·8	14·96	364·6	44	Nil	10·3
11	2 feet	9 3	·20	6·75	1·2	12·09	271·0	40	,,	8·75
12	3 ,,	9·4	·27	4·0	1·2	9 56	192 0	32	,	8 8
13	4 ,,	9·4	·30	6·25	2 8	7·4			,,	11 05
14	5 ,,	9 1	3 58	6 0	0·8	14 0			,,	5·9
15	6 ,,	9·1	2 58	8·0	0 40	13 2			,,	8·35
16	7 ,,	9·3	1 368	9·5	0 60	11 0			,,	9 9
17	8 ,,	9·2	1·236	9 25	1·2	12·4			,,	9·1
18	9 ,,	9·2	1 236	13·0	1·2	13·9			,,	10·0
19	10 ,,	9 4	·912	11·75	·8	11·9			,,	12 95
V. Bhatu Tehsil Fatehabad Distt. Hissar Block F 12 Sheet 17 P. No. 13										
2066	1 foot	8·7	28	2·15	2·0	17·1	239 2	74	Nil	22·0
67	2 feet	8 7	·20	1·5	2·2	17·8	560·0	78	,,	31·2
68	3 ,,	8·7	22	1·5	2·2	20·8	245·6	58	,,	41·5
69	4 ,,	8·	·27	1·15	2·4	19·06			,,	41·7
70	5 ,,	9·0	·28	·25	3·1	18·46			,,	40·2
71	6 ,,	9·0	·24	1·0	3·3	17·74			,,	40·4
72	7 ,,	9 5	20	·75	1·6	11·4			,,	10·0
73	8 ,,	9 5	·16	·75	1·0	10·36			,,	6·3
74	9 ,,	9 0	·22	·50	1·2	9·6			,,	7·5
75	10 ,,	9·5	·18	1·5	1·0	15·4			18 0	11·6
Village Tehang Tehsil Phillaur Distt. Jullundur 47 B.D.P. No. 16										
41211	1 foot	8·93	·07	5·25	2·4	20·2	235·9	57·4	27 97	13·82
12	2 feet	8 78	·08	4·0	1·2	17·3	208·0	46·4	20·96	11·59
13	3 ,,	8 84	·062	1·25	1·2	14·3	115·0	43·8	7·69	7·41
14	4 ,,	8·94	·068	1·25	1·2	8·4			10·14	4·16
15	5 ,,	9·0	·069	1·0	1·6	5·8			Nil	4·01
16	6 ,,	9 01	06	1·0	1 6	6 2			,,	5·21
17	7 ,,	9 10	·058	0·75	1·0	7·5			,,	4·30
18	8 ,,	9·23	·06	0·90	2·7	5 7			,,	4·11
19	9 ,,	9 38	·064	1·5	1·3	4·6			,,	4·27
20	10 ,,	9 2	0 065	1 25	1·5	4·6			,,	4·111

TABLE 3 (Concluded).

Showing analyses of soils from different tracts of Bhakra Soil Survey.

Lab. Regd. No.	Depth of profile	pH value	T.S. %	Total carbonate CaCo 3 %	Exchageable		Humus mg	Nitrogen mg	Kankar %	Clay %
					Na—k m. e.	Ca m.e				
1	2	3	4	5	6	7	8	9	10	11
Village Baniala Distt. Jullundur 51 B.D. Profile No. I										
43016	1 foot	8·4	·098	·75	2·4	9·6	239 6	67·2	1·6	21·59
17	2 feet	8·31	·09	·65	3·6	13·3	249·6	40 6	Nil	20·69
18	3 ,,	8 16	·15	·50	1·6	16·1	249·6	44·8	,,	18·74
19	4 ,,	8·18	·096	·75	5·1	16·6			,,	26·25
20	5 ,,	8 10	08	·50	2·6	15·5			,,	23 53
21	6 ,,	8·12	·082	·50	2·3	15 5			,,	23·45
22	7 ,,	8 15	·109	·50	2·1	14·7			,,	22·56
23	8 ,,	8·27	·08	·50	2·3	15·1			,,	22·49
24	9 ,,	8·40	·087	1·5	2·2	16·7			,,	20·75
25	10 ,,	8·39	·09	2 0	2·2	15-5			,,	20·29
Village Zarifabad Tehsil & District Karnal.										
3872	0—6″	8 6	·01	1·0	3·3	11 8	510·6	44 8	Nil	14 08
73	6–12″	8·5	·01	...	...	...	...	...	,,	12·8
74	2 feet	8 4	·01	·50	3·3	16·2	261·21	68·8	,,	10·40
75	3 ,,	8·5	·01	·50	2·8	11·8	224·21		,,	10·88
76	4 ,,	8·5	·01	·50	2 6	11·8			,,	8·8
77	5 ,,	8·5	·01	·50	2 8	15·1			,,	8·48
78	6 ,,	8 3	·01	·75	1·8	8·7			15 61	8·0
79	7 ,	8·2	·01	2·0	1·4	8 7			29 36	7·2
80	8 ,,	8·0	·01	·50	1·2	10·4			Nil	4·0
81	9 ,,	8·0	·01	·50	1·0	8·5			,,	2·24
82	10 ,,	8·1	·01	·50	1·0	6·3			,,	3·2
Village Gondar Tehsil and District Karnal										
4298	0″ 6″	9·1	·14	2·0	4 9	4·6	482·0	61·6		18 16
99	6″—12″	10 0	·33	2·2	9·5	6·4	136 0	35		18·56
4300	2 feet	10·2	·60	1 0	7·0	3·7	134·0	37		27·84
1	3 ,	10 2	·68	...	...	3·1				14·88
2	4 ,,	10 1	·66	1·0	15·2	...				14·96
3	5 ,,	10·0	·46	·75	11·4	4·4				14·32
4	6 ,,	10·1	·35	1·0	10 8	1·7				10·28
5	7 ,,	10·0	·23	·50	8·7	6·7				12·48
6	8 ,,	10·1	·23	·50	10·3	1 7				11·04
7	9 ,,	10·1	·20	2 0	9·2	1 9				7·44
8	10 ,,	10·0	·13	2 5	6·6	3 6				7·52

Table 4.

Showing analysis of soils from Khanna Samrala and Grey Canal Tracts of Bhakra Soil Survey.

Lab. Regd. No.	Depth of profile	pH value	T.S. %	Degree of alkalisation %	Calcium carbonate %	Clay %	Human mg.	Nitrogen mg.
Village Burki Kalan, Block F 10 Sheet 19 Profile No. 7 Tehsil and District Ludhiana.								
4 136	1 foot	8·68	0·09	22·2	·50	6·30	173 54	40·6
37	2 feet	8·31	·09	18·0	.50	10·48	272·0	42·0
38	3 ,,	8·24	·08	20·5	·50	11·57	280·0	39·2
39	4 ,,	8·24	·09	16·6	·50	12·14		
40	5 ,,	8·.0	·08	10.9	·50	10·88		
41	6 ,,	8·31	·10	12 2	·50	10 57		
42	7 ,,	8·49	·10	11 5	·50	8·95		
43	8 ,,	8·49	·09	12·3	·75	8·66		
44	9 ,,	8 46	·10	11·5	·75	5 94		
45	10 ,,	8·65	·12	13·7	1·0	5·88		
Village Bura Gujjar Block R 10 sheet 12, Profile No. 3 Tehsil Muktsar District Ferozepur.								
47982	1 foot	8·8	·07	10·6	1·0	4·35	160·0	35·0
83	2 feet	8·87	·062	12·5	1·75	7·20	238·8	38·0
84	3 ,,	8·63	·084	11·9	16 0	17·13	280·0	38 0
85	4 ,,	8·0	1·5	8 6	20·0	23 00		
86	5 ,,	7 99	2·0	6 9	16·5	21·87		
87	6 ,,	8 00	1 72	7·1	16·0	23·37		
88	7 ,,	8·11	·85	5·6	20 0	24·10		
89	8 ,,	8·10	·60	9·4	10·5	18·35		
90	9 ,,	8 23	·55	6·1	6·0	9 85		
91	10 ,,	8 23	·46	5·8	7·0	4·17		

Table 5

Showing detailed analysis of selected profiles.

Lab. Regd. No.	Clay %	pH	T.S. direct %	Sodium carbonate %	Sodium chloride %	Sodium sulphate %
Village Mirzapur Tehsil Hissar Block T 12 sheet 2 P. No. 11						
B 2910	10·3	9·2	·22	Nil	·02	·23
11	8 8	9·3	·20	Nil	·01	·18
12	8 8	9 4	·27	·03	·01	·23
13	11 1	9·4	·36	·07	·08	·21
14	5 9	9·1	3·58	·07	·23	3·26
15	8·4	9 1	2·58	·07	·32	2 01
16	9 9	9 3	1·37	·44	·30	·67
17	9·1	9·2	1·24	·17	·37	·76
18	10 0	9·2	1·24	·34	·28	·65
19	14 0	9·4	·91	·10	·20	·70
Village Ganga, Tehsil Sirsa District Hissar Block V 11 sheet 19 P.No. 12						
B 9945	13·7	8·6	·13	·21	·04	·05
46	16·8	8 6	4·50	·20	1·89	3 40
47	22·0	8·7	4·25	·12	1·81	3·17
48	22·1	8·7	4·00	·10	1·75	3 17
49	22 1	8·7	3·90	·11	1·86	2·49
50	14·6	8·8	3·55	·04	1·39	2·49
51	13·5	8·7	3 50	·04	1·47	1·95
52	12·1	8·8	1·35	·07	·49	·67
53	6·2	9·1	·23	·22	·02	·07
54	4·0	9·2	·24	·04	·03	·07

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APPENDIX—'C'

Annexure No. II

PUNJAB GOVERNMENT GAZETTE
EXTRAORDINARY
PUBLISHED BY AUTHORITY.

SIMLA—E., WEDNESDAY, JANUARY 21, 1953.

LEGISLATIVE DEPARTMENT

NOTIFICATION

The 21st January 1953.

No 2-Leg/53. The following Act of the State Legislature received the assent of the Governor of Punjab on the 5th January 1953, and is hereby published for general information :—

PUNJAB ACT NO. II OF 1953.

THE PUNJAB BETTERMENT CHARGES AND ACREAGE RATES ACT, 1952.

An Act to provide for the levy of betterment charges and acrage rates on certain lands in the State of Punjab.

It is hereby enacted as follows :—

Short title, extent and commencement.

1. (1) This Act mey be called the Punjab Betterment Charges and Acreage Rates Act 1952.

(2) It extends to the whole of the State of Punjab.

(3) It shall come into force at once.

Definitions

2. In this Act, unless the context otherwise requires:—

(a) "acreage rates" means the charges levied under section 6 on lands included in an irrigation scheme ;

(b) "Canal" includes :—

(i) all parts of a river, stream, lake or a natural collection of water or natural drainage channel to which the provisions of Part II of the Northern India Canal and Drainage Act 1873 (VIII of 1873), apply ;

(ii) all canals, channels, reservoirs, wells, tubewells and lift irrigation arrangements constructed, maintained or controlled by the Government for the supply or storage of water ;

(iii) all works, embankments, structures, supply and escape channels connected with such canals, channels, reservoirs, wells, tubewells or lift irrigation arrangements ;

(iv) all water courses, that is to say all channels which are supplied with water from a canal but which are not maintained at the cost of the Government, and all subsidiary works belonging to any such channels ;

(d) "Cost of an irrigation scheme" means the total financial liability accruing from the loan contracted or the investment made, the interest thereon,the cost of maintenance and operation of the scheme or any extension thereof or of an extention as a result thereof, with reference to the period during which the said liability has to be discharged.

(e) "Government" means the Government of the State of Punjab;

(f) "Irrigation Scheme" means any such scheme as is referred to in section 3 ;

(g) "Landowner" has the meaning assigned to it in the Punjab Land Revenue Act, 1887 (XVII of 1887) ;

(h) "prescribed" means prescribed by rules made under this Act ;

(i) the expressions "land", and 'tenant" and "occupancy tenant" have the meanings respectively assigned to them in the Punjab Tenancy Act, 1887 (XVII of 1887) ;

(j) the expressions " anal Officer and "Divisional Canal Officer" have the meanings respectively assigned to them in the Northern India Canal and Drainage Act, 1873 (VIII of 1873);

Irrigation schemes and notification of proportion to levy betterment charges.

3. Where any scheme has come or comes into operation after the 15th day of August, 1947, for any one or more of the following purposes namely :—

(i) the irrigation of lands from any existing or projected canal ;

(ii) the extension of irrigation of land situated within the approved irrigation boundary of an existing canal;

(iii) the improvement of irrigation supply or capacity factors or water allowances to lands already irrigated ;

(iv) the provision for or the improvement of drainage or any reservoir, dam or embankment constructed, maintained or controlled by the Government for the supply or storage of water ;

the Government may proceed to levy betterment charges in respect of the lands which are included or are likely to be included in the irrigation scheme by notifying in the official Gazette a copy of which shall be posted at a conspicuous place in the village affected and in such other manner as may be prescribed its intention so to do, and shall specify in such notification such particulars respecting the type and extent of irrigation proposed:

Provided that no betterment charges shall be levied in relation to an irrigation scheme where the charges ordinarily leviable under other laws for the time being in force are sufficient to cover the cost of the scheme:

Provided further that the amount of the betterment charges recoverable from any scheme will be limited to the difference between the investment on the scheme and such part of it as may make it productive

Explanation I. "Capacity factor" means the ratio of the mean supply to the authorised full supply discharge of a channel, and "mean supply" for a period connotes a sum of the daily supply in cusecs divided by the number of days during that period.

Explanation II. "Water allowance" means the designed number of cusecs of outlet or distributary capacity per thousand acres of land included in an irrigation scheme.

Explanation III. "Cusec" is the unit of discharge and means the rate of flow of one cubic foot of water per second.

Procedure for levy of betterment charges.

(1) At any time after the expiry of one month from the date of the publication of the notification referred to in section 3 the Government may cause a schedule of betterment charges to be prepared for all lands or class of lands included in an irrigation scheme showing the rates at which the charges shall be leviable on the lands and payable by the landowners and occupancy tenants thereof and the proportions in which the charges shall be so payable.

(2) In preparing a schedule under sub-section (1) for the levy of betterment charges in respect of any irrigation scheme regard shall be had to the following, namely :—

(a) the type of irrigation;

(b) the improvement in irrigation;

(c) the extent of betterment accruing to the lands.

(3) A draft of the schedule prepared under sub-section (1) shall be published in the official Gazette, a copy of which shall be posted at some conspicuous place in the area affected and in such other manner as may be perscribed.

(4) Any landowner or occupancy tenant who may be affected by the proposed betterment charges may, within sixty days from the date of the publication in the village whichever is later, present a petition in writing to the Government stating his objections, if any, to the levy of the betterment charges or the rate thereof.

(5) After considering the objections and after making such further enquiry into the matter as the Government may think fit, the Government shall determine the final schedule of betterment charges and cause the same to be published in the official Gazette, and in such other manner as may be prescribed.

5. (1) The amount of the betterment charges leviable in respect of any lands included in an irrigation scheme shall not exceed one-half of the difference between the value of the lands with reference to such date prior to the commencement of any work in connection with the irrigation scheme as the Government may, by notification in the official Gazette, fix in this behalf and their estimated value with reference to such other date after such commencement as the Government may similarly fix, and such valuations shall be made in the prescribed manner.

(2) Where in an irrigation scheme only lift irrigation arrangements are maintained and operated by the landowners or occupancy tenants, the betterment charges leviable shall not exceed one-half of the charges which would otherwise have been payable for gravity flow irrigation.

Provided that whenever such lift irrigation arrangements are converted into gravity flow irrigation, the landowners or occupancy tenants, as the case may be, shall be liable to pay the full betterment charges in respect of the lands.

Levy of acreage rates.

6. (1) Where in respect of any lands included in an irrigation scheme expenditure has been or is likely to be incurred by the Government in the execution of any one or more of the following works or in understanding any one or more of the following measures, namely :

(a) rectangulation, sub-rectangulation, or killa-bandi (that is to say, sub-division of land into one acre fields),

(b) level, topographical or soil surveys,

(c) construction of watercourses,

(d) construction of village roads and works appertaining thereto,

the Government may, for the purpose of recouping or meeting such expenditure, cause a schedule of acreage rates to be prepared showing the rates at which they shall be leviable on the lands, and the manner in which and the persons by whom they shall be payable.

(2) A draft of the schedule prepared under sub-section (1) shall be published in the official Gazette, a copy of which shall be posted at some conspicuous place in the area affected and in such other manner as may be prescribed.

(3) Any landowner or occupancy tenant who may be affected by the proposed acreage rates may, within sixty days from the date of the publication of the schedule in the official Gazettee, present a petition in writing to the Government stating his objections, if any, to the levy of acreage rates or the incidence thereof.

(4) After considering the objections and after making such further enquiry into the matter as the Government may think fit, the Government shall determine the final schedule of acreage rates and cause the same to be published in the official Gazette and in such other manner as may be prescribed.

Finality of schedule of betterment charges and acreage rates.

7. The betterment charges and the acreage rates leviable under the final schedules as published under sub-section (5) of section 4 and sub section (4) of section 6 shall be final and no court shall call in question the schedules so published or the levy or rates of such charges or the determinarion by the Government of the increase in value of lands for the purpose of levying betterment charges.

Demand of betterment charges and acreage rates.

8. (1) When the schedule of betterment charges or acreage rates has been published in the official Gazette under sub-section (5) of section 4 or sub section (4) of section 6, the Canal Officer shall prepare a dem-

and statement in respect thereof in such form as may be prescribed containing full particulars of the amount which each landowner or occupancy tenant shall be liable to pay and cause a notice of demand to be served on him.

(2) Any landowner or occupancy tenant may within such period as may be prescribed from the date of the notice of demand, present a petition to the Divisional Canal Officer or the Deputy Collector objecting to the demand or any part thereof, and the petition shall be disposed of in such manner and orders passed thereon shall be subject to such appeals as may be prescribed.

(3) Any amount due under a notice of demand shall, subject to any orders that may be passed on appeal under sub-section (2), be payable within such time as may be prescribed.

Mode of recovery of betterment charges and acreage rates.

9. (1) The betterment charges and the acreage rates may be paid in one or more instalments as may be prescribed.

Provided that where the betterment charges or acreage rates are paid in instalments interest shall be payable in respect of such instalments at such rates as may be prescribed and such interest shall be recovered in the same manner as the betterment charges or the acreage rates.

(2) Notwithstanding anything contained in this section, the Government may, subject to such conditions as may be prescribed, allow a landowner to relinquish any part of his land in favour of the Government in satisfaction of the betterment charges payable in respect thereof.

Postponement of recovery of betterment charges and acreage rates in certain cases.

10. Where there has been a failure of crops in any area, the Government may, notwithstanding anything to the contained in this Act or the rules made thereunder, postpone for such period as it thinks fit the recovery of any such charges or rates, whether wholly or in part.

Apportionment of betterment charges and acreage rates.

11. The betterment charges and acreage rates shall be recoverable from the landowner and occupancy tenant concerned in such proportions as may be prescribed :

Provided that in making any such apportionment between the landowner and the occupancy tenant of the same land due regard shall be had to the prevailing practice in respect of the division of produce or capital values between such person in respect of that land;

Provided further that where there are more landowners than one they shall be jointly and severally liable for the portion recoverable from the landowner, and similarly where there are more occupancy tenants than one they shall be jointly and severally liable for the portion recoverable from the occupancy tenants.

Betterment charges and acreage rates to be a charge on the land

12. Any sums lawfully due under this Act by way of betterment charges or acreage rates shall take priority over all other charges payable in respect of the land except land revenue and shall be deemed to that extent to be a charge on the land and shall be recoverable as an arrear of land revenue.

Betterment charges and acreage rates not to affect any other charges leviable.

13. The betterment charges and acreage rates payable under this Act in respect of any land shall not affect any other rates or charges leviable under any other law for the time being in force.

Bar to jurisdiction Civil Courts.

14. No civil court shall have jurisdiction in respect of any matter relating to anything done or to be done under this Act.

Indemnity from proceedings.

15. No claim shall lie against the Government for compensation or for the refund of betterment charges or acreage rates on account of loss occasioned by the failure or stoppage of water in a canal or by any cause beyond the control of the Government or by any repairs, alterations or additions made to the canal by the Divisional Canal Officer or by any measures taken by him for regulating the proper flow of water therein or for maintaining the established course of irrigation in cases where the Divisional Canal Officer considers such action to be necessary.

Indemnity.

16. No suit prosecution or other legal proceeding shall lie against any person in respect of anything done or intended to be done in good faith under this Act or the rules made thereunder.

Power of Canal and Revenue Officers to summon persons.

17. (1) The Divisional Canal officer, Canal Collector, Deputy Collector or a Revenue Officer of the rank of a Deputy Commissioner or Assistant Collector may summon any person whose attendance he considers necessary for the purpose of any business before him under this Act.

(2) Any person so summoned shall be bound to appear at the time and place mentioned in the summons, in person or, if the

summons so allows, by his recognised agent or a legal practitioner.

(3) The person attending in obedience to the summons shall be bound to state the truth upon any matter respecting which he is examined or makes statements, and to produce such documents and other things relating to any such matter as the summoning officer may require.

Penalty for failure to attend limits of estate obedience to order of Canal and Revenue Officers.

18. If a person required by a summons, notice, order or proclamation proceeding from a summoning officer to attend at a certain time and place within the limits of the estate in which he ordinarily resides or in which he holds or cultivates land, fails to comply with the requisition, he shall be liable, at the discretion of the summoning officer, to a fine which may extend to fifty rupees, which, if not paid in cash, shall be recoverable as arrears of land revenue.

Power to make rules.

19. (1) The Government may, by notification in the official Gazette, make rules to carry out the purposes of this Act.

(2) In particular and without prejudice to the generality of the foregoing power, such rules may provide for all or any of the following matters, namely :

(a) the manner in which notices under this Act, or the schedules of betterment charges rates shall be published;

(b) the manner in which valuation may be made of any lands for the purpose of sub-section (1) of section 5 and for determining their increase in value;

(c) the manner in which rates of betterment charges shall be calculated with reference to any lands or class of lands in an irrigation scheme;

(d) the form in which demand statements may be prepared under sub-section (1) of section 8 and the procedure for preparing the same;

(e) the form in which notices of demand may be prepared under this Act and the manner of their service;

(f) the time within which objections may be preferred from notices of demand under sub-section (2) of section 8, the procedure for the determination of such objections and the authorities to whom and the manner in which and conditions subject to which appeals may be preferred therefrom;

(g) the time within which betterment charges and acreage rates shall be payable after the notice of demand and the manner in which such charges or rates may be realised ;

(h) the conditions subject to which any sum due under this Act may be paid in instalments and the rate of interest for the payment of such sum in instalments ;

(i) the conditions subject to which any land-owner may be allowed to relinquish any part of his land to the Government in satisfaction of betterment charges due from him.

(j) the manner in which betterment charges and acreage rates may be apportioned between landowners and occupancy tenants;

(k) the manner in which and the conditions subject to which any officer shall exercise his powers under this Act.

(l) any other matter requiring to be prescribed under this Act.

Repeal.

20. The Punjab Betterment Charges and Acreage Rates Act, 1952 (President's Act No, III of 1952), is hereby repealed, but notwithstanding such repeal, anything done or any action taken in the exercise of any power conferred by or under the repealed Act shall be deemed to have been done or taken in exercise of the powers conferred by or under this Act so far as consistent with the provisions of this Act.

P.M. ISMAIL,
Secretary to Government, Punjab,
Legislative Department.

Annexure No. III

GOVERNMENT OF THE PUNJAB STATE (INDIA)
PUNJAB PUBLIC WORKS DEPARTMENT, IRRIGATION BRANCH.

Rules issued under "Punjab Betterment Charges and Acreage Rates Act, 1952."

In exercise of the powers conferred by Section 19 of the Punjab Betterment Charges and Acreage Rates Act, 1592, the Governor of Punjab is pleased to make the following Rules to carry out the purposes of the aforesaid Act.—

RULES

1. These Rules may be called the Punjab Betterment Charges and Acreage Rates Rules 1954.

Short Title.

2. In these Rules :—

Definitions.

(a) "The Act" means the Punjab Betterment Charges and Acreage Rates Act, 1952.

(b) "Perennial Irrigation" means canal irrigation available throughout the year.

(c) "Restricted Perennial Irrigation" means canal irrigation available throughout the year except during the months of July and August.

(d) "Kharif Irrigation" means canal irrigation available during the months of April to September, both inclusive.

(e) "Rabi Irrigation" means canal irrigation available during the months of October to March, both inclusive.

(f) "Included lands" means lands for which canal water has been provided in a duly sanctioned chakbandi under any irrigation scheme coming within the purview of this Act. Any Area subsequently incorporated in the scheme shall also be considered to be "included lands."

(g) "Board" means a Committee consisting of a Revenue Officer of the rank of a Collector and a Canal Officer of the rank of a Divisional Canal Officer, appointed by Government for appraisement of the enhancement in the value of lands included in an irrigation scheme for the purpose of levy of Betterment Charges.

(h) "Chief Engineer" means Chief Engineer for the time being in charge of the scheme for the purpose of levy of Betterment Charges.

Mode of publication.

3. Any proposal by Government to levy Betterment Charges on lands included in any irrigation scheme or any other matter requiring publicity under the Act, shall be published in the Official Gazette and certified copies and translations thereof in Hindi, Gurmukhi or Urdu shall be posted : –

(a) at the office of the Deputy Commissioner and Divisional Canal Officer concerned;

(b) at conspicuous places in the locality affected by the proposal such as Tehsils and Thanas etc., and by best of drum or oral proclamation or other customary methods.

Method of appraisement of enhancement in value of land.

4. (1) The entire area included in an irrigation scheme shall be divided by the Board into blocks or assessment circles so as to have more or less uniform physical characteristics of soil in each block or circle, as per classification in the last settlement, taking note of any changes which may have affected the productivity of the soil or the area concerned.

(2) Share of the landowner in the net assets will be taken as 1/3rd of the total net assets for purposes of evaluating cost of land.

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(3) The Board shall similarly estimate share of net assets of a landowner for the subsequent date as fixed by Government in this behalf under Section 5 of the Act.

(4) Value of the land of an owner or an occupancy tenant will be taken as 30 times the value of his share of net assets.

(5) Increase in value of each class of land in an assessment circle from the date prior to and subsequent to the commencement of any work in connection with the irrigation scheme will be considered as the enhancement in the value of land resulting from introduction or improvement in the irrigation facilities.

(6) The rate of betterment charges will be such portion of the enhanced value, but not exceeding half of it, as the State Government may determine.

(7) The Betterment Charges shall be calculated with reference to classes of lands recorded in the last settlement or the latest

Revenue record available and also with reference to different types of land.

(8) In cases where canal irrigation facilities are made available to Chahi areas and where actual value of such lands is not likely to increase, the calculation of betterment charges will take into account the reduction in the cost of the working of wells and their maintenance.

Publication of Draft Schedule of Betterment Charges.

5. A draft of the schedule of betterment charges prepared under Section 4 (1) after approval by Government, shall be published in the Official Gazette and in the manner provided in Rule 3. This schedule will include information regarding rates per acre payable as betterment Charge for each class of land.

(a) when paid in lumpsum,

(b) when paid by instalments.

(c) maximum number of instalments allowed for payment.

Disposal of objections to schedule of Betterment Charges.

6. Any aggrieved landowner or occupancy tenant may present a petition in writing to Government through the Divisional Canal Officer within 60 days of publication of Draft Schedule in the Official Gazette or from the date of its publication in the village whichever is later, stating his objections to the levy of Betterment Charges or the rates thereof. The Divisional Canal Officer shall transmit the petition to the Board as soon as possible, and the Board shall consider the objections and submit their report thereon to the Government through the Chief Engineer.

Publication of Schedule of Betterment Charges.

7. After considering the report of the Board, and after further enquiry, if any, the Government shall determine the final schedule of betterment charges and publish the same in the manner laid down for publication of the draft schedule in Rule 3 above.

Procedure for altering rates of Better-Charges when improvement is made in an irrigation scheme already subjected to levy of Betterment Charges.

8. (a) If lift irrigation arrangements in regard to any land included in a scheme are subsequently converted into gravity flow irrigation, the full betterment charges will be leviable on the assessee who shall be required to pay the higher rate of betterment charges from the date the said conversion is

effected, till taking into account the previous payments, the total amount of betterment fee calculated on the basis of improved irrigation facilities has been recovered.

(b) If irrigation arrangements in regard to any land included in a scheme are subsequently improved as mentioned below, the full betterment charges will be leviable on the assessee who shall be required to pay the higher rate of betterment charges from the date the said conversion is effected, till, taking into account the previous payments, the total amount of betterment fee calculated on the basis of improved irrigation facilities has been recovered :—

(i) Conversion from non-perennial to perennial.

(ii) Conversion from restricted perennial to perennial.

(iii) Increase in water allowance and permissible intensity of irrigation.

Procedure for working out Acreage Rates.

9. The acreage rate shall be worked out by the Divisional Canal Officer on the basis of the estimated cost of one or more works or measures mentioned in Section 6(1) of the Act after consulting, where necessary, the Revenue or Colonization Officer concerned. The Divisional Canal Officer will then submit his proposals to the Government through Chief Engineer Incharge of the Scheme.

Publication of Schedule for Acreage Rates

10. The procedure for publication of the draft schedule of acreage rates and for receiving objections of persons by whom they are payable and for publication of final schedule will be the same as that for Betterment Charges under Rules.

No objection to be entertained to various Schedule on the change of ownership after the expiry of dates for receiving objections.

11. No transfer of ownership after the period of limitation prescribed for objections to draft schedules for betterment charges or acreage rates or on any day after the publication of the final schedule shall give any right to the transferee for making fresh objections.

Distribution of Demand Slips.

12. As soon as the demand statements in respect of betterment charges or acreage rates for any village are completed, the Divisional Canal Officer shall forward the demand slips meant for assessees to the Canal Patwari who will deliver these to Lambardar concerned within 5 days of their

receipt by him. The Lambardar will serve them among assessees or, in case of their absence, to their recognised agents or an adult male member of the family of an assessee within 7 days of receipt of these demand slips from Patwari. The acknowledgments of assessees or of their agents or adult member of the family for demand slips shall be submitted by Lambardars to Divisional Canal Officer by registered post or through the Canal Ziladar concerned within 10 days of their receipt from the Canal Patwari.

Submission of Demand Statement to Tehsils.

13. One copy of demand slips consolidated in the form of a Demand Statement for each village shall be sent to Tehsil concerned on the same dates as are fixed by the Financial Commissioner for despatch of demand Statements for Occupier's Rates by Divisional Canal Officer for each crop.

Objections by assesses to Demand and their disposal.

14. (a) Any landowner or occupancy tenant may present his objections against the demand to the Divisional Canal Officer or the Deputy Collector concerned within 30 days of the date of service of the demand slip on him, or on his agent or an adult member of his family, or if the demand slip has been proved not to have been delivered to him or his agent or adult male member to the satisfaction of the Divisional Canal Officer or the Deputy Collector, as the case may be, within 20 days of the date on which he first got notice of the demand against him.

(b) The orders of Divisional Canal Officer or the Deputy Collector, as the case may be, within 20 days of the date on which he first got notice of the demand against him.

(c) The orders of Divisional Canal Officer or the Deputy Collector as the case may be on such objection will be appealable to the Commissioner of the Division concerned within 30 days of of the date of such orders.

(d) No objection to the demand at the time of collection of betterment charges or acreage rates shall be entertained and the collection shall not be suspended except on the receipt of an intimation from the Divisional Canal Officer that an objection has been admitted by him.

Procedure of recoveries.

15. Any amount due from an assessee under a notice of demand for betterment charges or acreage rates shall on demand be payable to the Lambardar concerned.

The procedure for recovery will be the same as that for the recovery of land revenue.

Option of assessee for mode of payment.

16. On publication of the final schedules of Betterment Charges under Section 4 (5) and of acreage rates under Section 6 (4) of the Act, the Divisional Canal Officer shall publish a notice in the village affected thereby that the landowner or occupancy tenant should intimate to him through an application, in writing, within 30 days of the notice his option with regard to the manner of payment by him. The notice will state that the option is to be exercised between :—

(a) one lumpsum payment;

(b) by half-yearly instalments spread over a number of years as decided by Government, maximum number of instalments not exceeding 30;

(c) offering a part of his land in lieu of full or part payment of betterment charges due from him.

If no intimation is received by the Divisional Canal Officer from any landowner or occupancy tenant within the prescribed period, the recoveries will be made from him in instalments.

Assessee can alter his option subsequently.

17. The land owner or occupancy tenant will have the option after payment of first or any subsequent instalment to pay the balance in one lumpsum according to the amount outstanding against him less interest charges included in the balance for payment by instalments.

Rate of interest on instalments.

18. In computing the amount of each instalment, simple interest at 4½% per annum shall be taken into account. Similarly 4½% simple interest will be charged on all sums not paid on due date.

Conditions of surrender of land in lieu of Betterment Charges.

19. Surrender of land by any assessee in lieu of full or part payment of betterment charges shall be accepted only if :-

(a) the area to be surrendered is free from all encumberances.

(b) it does not reduce the holding of assessee to less than 20 ordinary acres.

(c) the area to be surrendered is in a compact block of not less than 5 ordinary acres.

Evaluation of land offered for surrender in lieu of Betterment Charges.

20. Where land in lieu of betterment charges has been accepted by the Divisional Canal Officer after due investigation, he will evaluate the area surrendered at such rates as may have been fixed by the Board for such class of land with reference to the date subsequent to the commencement of the irrigation scheme under Section 5 (1). The decision of the Divisional Canal Officer shall be subject to the final approval of Superintending Canal Officer.

Disposal of lands surrendered.

21. The land accepted in lieu of betterment charges shall be disposed of in such manner as Government may from time to time prescribe and the proceeds thereof shall be credited to the irrigation scheme concerned.

Postponement of recoveries.

22. The postponement of recoveries, under Section 10 of the Act, shall be for such areas only for which occupiers' rate is remitted under Parts II, III and IV of the Rule 20 of the Northern India Canal and Drainage Act VIII of 1873. The postponement for recovery of charges shall be made only if more than half the area receives remission under the said Rule and will be only for the harvest in which the aforesaid failure has occurred.

Apportionment of dues between owners and occupancy tenants.

23. The apportionment charges and acreage rates between the landowners and the occupancy tenants will be carried out by the Divisional Canal Officer or the Deputy Collector or other Revenue Officer of the District concerned, in accordance with their rights as existing in the Revenue Records.

Apportionment of dues among joint ownerships.

24. If any land on which betterment charges are levied, is owned by more than one person, the Divisional Canal Officer or the Deputy Collector or other Revenue Officer, on receipt of an application from any one of the owners will distribute betterment charges amongst all owners according to their shares in the said land as per Revenue records. Each owner will be jointly and severally liable for full payment The same procedure will also apply to fields in possession of more than one occupancy tenant.

Rules regulating the service of summons and notices etc.

25. Except as otherwise provided in these Rules every summons, notice, order and requisition which, under the Act, or the Rules made thereunder, is required to be served on, issued, delivered or communi-

cated to any person, shall be so served, issued, delivered, or communicated, as the case may be, as hereinafter provided : -

(1) Every such summons, notice, order or requisition shall be drawn up in writing and dated and signed by the officer having authority to issue or make the same under his seal.

(2) Every summons, notice, order or requisition which is required to be served on or delivered or communicated to any person shall whenever possible, be so served, delivered or communicated : —

(a) personally on or to whom it is addressed, or failing him,

(b) on or to his recognised agent, or failing such agent,

(c) on an adult male member of his family usually residing with him.

(3) If service, delivery or communication cannot be so made or effected or if acceptance is refused ; the summons, notice order or requisition may be served, delivered or communicated by posting a copy thereof, at the usual or last known place of residence of the person to whom it is addressed, or to be communicated, or if that person does not reside in that district, then in such manner as the officer authorised to issue or make the same may direct.

(4) If the summons, notice, order or requisition relates to a case in which persons having the same interest are so numerous that personal service on each one of them is not reasonably practicable, it may be served, delivered or communicated by delivery of a copy thereof to such of those persons as the officer authorised to issue or make the same, specially nominates in this behalf, and by proc'amation of the contents thereof for the information of the other persons interested.

(5) A summons, notice, order or requestion may be served on or delivered or communicated to the person named therein, either in addition to, or in substitution for, any other mode of service by farwarding the summons, notice, order or requisition by post, in a registered letter addressed to that person.

(6) When a summons, notice, order or requisition is so forwarded in a letter, and it is proved that the letter was properly addressed and duly posted and registered, the officer authorised to issue or make the same may presume that the summons was served at the time when the letter would be delivered in the ordinary course of post.

(7) In every case in which service of any process is not effected personally, the officer authorised to issue the same shall satisfy himself, by examining the process server or otherwise, that such service has been duly effected in the manner required by these rules.

Grant of abatement of Betterment Charges.

26. (a) If any area during the currency of payment of betterment charges becomes Thur, water-logged or in any way becomes unfit for cultivation in the opinion of the Chief Engineer the betterment charges for the remaining instalments will be suspended. Payments already made shall not be rafundable.

(b) Similarly if the irrigation scheme on account of which betterment charges are levied, fails at any stage for any of the reasons specified in section 15 of the Act, the recovery of unpaid instalments of betterment charges may remain in suspension till such time as the scheme is not fully restored. The decision of Divisional Canal Officer in respect of the aforesaid suspension and the duration of the failure shall be final.

Exemption not permitted.

27. Where a landowner or occupancy tenants fails to irrigate during any crop, himself or though his tenant a part or whole of his area included in the irrigation scheme, no exemption will be granted in respect of Betterment Charges or acreage rates payable in respect of such un-irrigated areas.

Acceptability of Civil Records as evidence.

28. Every entry recorded in the Revenue Records shall be relevent as evidence in any dispute as to the matters relating to the assessment of Betterment Charges and acreage rates and shall be presumed to be true until the contrary is proved or a new entry is lawfully substitued therefore in accodance with the procedure prescribed by law.

Methods of dealing with alteration in demand.

29. If after delivery of the demand slips to the asseesees any addition is made to the demand, or any suspension is allowed on any account admissible under the Act or rules thereunder, such addition shall be communicated to the owner or occupancy tenant, as the case may be, means of supplementary demand slips. Demand shall be shown in black ink and suspension in red ink. All such alterations as are made before the despatch of the Demands Statement to the Tehsil concerned under rule 13 supra shall be included in that document and shall also be written on slips similarly printed and attached to the Demand Statement. Alterations made after the despatch of the Demand Statement shall be intimated to the Tehsil concerned in a supplementary consolidated statement after 60 days. Any addition or suspension allowed thereafter shall be similarly incorporated in the Demand Statement for the succeeding harvest. Due intimation will be given about additions and suspension to assesses concerned by issue of supplementary demand slips in manner prescribed in Rule 12.

Minimum amount for additions and remission.

30. No additional demand shall be prepared and no suspension shall be granted where the amount for any individual demand amounts to Re. 1/- or less for acreage rates, or for betterment charges.

Demand for Betterment Charges and acreage rates not to lapse.

31. The dues on account of betterment charges or acreage rates shall not lapse on account of their not having been demanded within a certain period.

Inrecoverable balances

32. When balances are found to be irrecoverable, owing to want of assets, absconding of defaulters or any other cause, they shall be reported to the Collector and to the Commissioner, who, if he sees fit will forward each case to the Financial Commissioner for such action as may be necessary under the orders of the Government.

Lambardars to issue receipts for collections.

33. Receipts shall invariably be given by the Lambardar or other person making the collection to each owner or occupancy tenant on payment of Betterment Charges or acreage rates on a prescribed printed form.

Unit of area for calculation of Betterment Charges and Acreage Rates.

34. (a) For purposes of calculating acreage rates, fraction of less than half acre shall be ignored and areas of more than half and less than one acre shall be counted as one acre.

(b) For calculating the betterment charges, the exact area shall be the basis of charge.

Demand Statement to be accessible to assessees.

35. The Canal Patwari shall be responsible that the village copy of the Demand Statement is at all times accessible to any person who is liable to pay betterment charges or acreage rates.

MISCELLANEOUS.

Condonation of period of limitation in certain cases.

36. An appeal may be admitted after the period precribed upto 6 months when the appellant satisfies the appellate authority that he had sufficient cause for not presenting the appeal within such period.

If the period expires on a day when office of the appellate authority is closed, the appeal my be presented on the day the office re-opens.

Calculation of period.

37. The period prescribed shall be calculated from the date of decision or order appealed from and in computing such period the day when the decision or order was made, and the time requisite for obtaining a copy of the decision or order appealed against shall be excluded.

Form of appeal.

38 The application for admission of an appeal shall be stamped in accordance with the law in force relating to Court Fess, and shall be accompanied by a copy of the decision or order appealed against, and shall state concisely the grounds upon which the appeal is preferred.

When appeal may be summarily rejected.

39. The application may be rejected, if. upon a perusal of the grounds of appeal and the copy of the decision or order appealed against, it appears to the appellate authority unnecessary to call for the proceedings.

Procedure on admission of appeal.

40 If the application be granted, an entry thereof shall be made in a register of appeals numbered consecutively, and a day shall be fixed for the hearing of the appeal.

Notice of hearing to be given.

41. Notice of the date and place fixed for hearing of the appeal shall be given to the appellant in such manner as the appellate authority may direct, and to every other party to the case whose interest is opposed to that of the appellant in the manner hereinafter prescribed.

Contents of notice.

42. A written notice containing the title of the appellate authority, the names of the parties, the date and place fixed for the hearing of the appeal, and such

other particulars as the appellate authority may, by general or special order, direct, shall be issued in duplicate under the hand and seal of the authority.

Mode of Service.

43. All notices and processes issued in connection with appeal shall be served in the manner prescribed in connection with the service of summons and notices generally.

Acknowledgment of personal service.

44. When personal service is effected, the addressee shall be required to acknowledge the service by affixing his signature, seal or mark on the back of the duplicate copy to be retained by the serving officer.

Memorandum by Serving Officers.

45. The Serving Officer shall in every case endorse on the duplicate copy a memo signed by him of the date and mode of service, and return each copy to the authority which issued it.

Hearing may be postponed or adjourned.

46. The hearing of an appeal may be postponed or adjourned from time to time as the appellate authority may see fit, by written order to direct, to any subsequent date, and notice of such date shall be given to the parties in such manner as the authority may direct.

Court to be satisfied before hearing that notice has been received by parties.

47. The appellate authority shall not proceed to the hearing of any appeal unless and until it is satisfied that notice of the date and place fixed for such hearing has been received by the parties concerned in sufficient time to permit them to appear or to be represented at such hearing. Provided that the appellate authority may presume that notice has been received when a written notice has been served in any of the ways described in these rules. Provided also that an appeal may be heard and decided, notwithstanding the absence of any party who is shown to satisfaction of the authority to be wilfully evading service of notice.

48. Procedure on hearing :—

What parties present

(a) The appellate authority, before passing order or decision on the appeal, shall record in writing which (if any) of the parties to the appeal are present, in person or by representative, at the hearing thereof.

Further enquiry by applleate court.

(b) The appellate authority, if it thinks further enquiry necessary, may conduct such enquiry itself.

The decision or order of court.

(c) When the hearing of the appeal is concluded, the decision or order of the appellate authority, shall, when practicable be pronounced forthwith and shall be recorded in writing signed by the appellate authority, and the substance thereof shall be explained to such of the parties or their representatives, as are present when the decision or order is pronounced or given.

Translation thereof.

(d) Every decision or order recorded in English shall be translated into Hindi or current language of the locality, and the translation shall be authenticated by the signature of the appellate authority and filed with the proceedings.

Copy thereof to be sent to Subordinate Officer.

49. A copy of decision or order shall be transmitted by the appellate authority to the officer from whose decision or order the appeal was preferred.

Copies to be granted to parties.

50. A copy of the decision or order of the appellate authority, in English, Hindi, or Punjabi shall be granted to any person concerned or interested therein, who shall apply for the same, upon payment of proper court fees and copying charges.

Re-hearing in certain events.

51 In any case in which and order on appeal is passed ex-parte against a person, he may apply to the appellate authority by which the order was passed for an order to set it aside ; and if he satisfies the authority that the summons or notice was not duly served, or that he was prevented by any sufficient cause from appearing when the appeal was called on for hearing, the authority shall make an order setting aside the order as against him upon such term as it think fit, and chall appoint a day for proceeding with the appeal.